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TRITHEMIUS AND ALCHEMY.

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JOHANNES TRITHEMIUS was born in 1462 [1] at Trittenheim near Trier on the Moselle, and takes his name from that of his birthplace. After assiduous but unsystematic study at Trier and Heidelberg he left for home in 1482, travelling on foot. He got as far as Sponheim, a mile from Bingen, where deep snow drove him to shelter in the Benedictine cloister of St. Martin, where he decided to become a novitiate. Later in the year he made profession, and in 1483 [2], at the age of barely twenty-two, he was elected Abbot of Sponheim, an office which he filled for twenty-three years. During this period he re-established

[1] Moehsen, *Geschichte der Wissenschaften in der Mark Brandenburg*, 4°, Berlin and Leipzig, 1781, 449, is the only author I have seen who gives 1464 as the date of birth. In the *Beiträge* to this work, Berlin and Leipzig, 4°, 1783, 29, Moehsen ranks Trithemius, Albertus Magnus and Thomas Aquinas among the adepts, or those who ' at least worked in the art '.

[2] Moehsen says in 1488.

the discipline and fostered the studies of the monks, repaired the monastery, increased its library from 48 to 2000 books, and established for himself a great reputation for learning. In 1505 he went to Heidelberg to advise the Count Palatine on the site of a monastery, and during his absence disaffection broke out at Sponheim. After sojourning at Cologne and Spires, Trithemius, in 1506, became Abbot of the Scottish monastery of St. James at Würzburg, where he died in 1516 [3]. In 1508 he stayed for a short time at the court of the Emperor Maximilian [4].

Trithemius was a voluminous writer both of books and letters; his works are now little esteemed, and there is no recent account of him. His separate works on history and theology are most conveniently consulted in two collections: (1) the *Opera Historica*, edited by Marquardt Freher, in two folio volumes, Frankfurt, 1601 [5], and St. Gall, 1690 [6]; and (2) the *Opera Pia et Spiritualia*, edited by John Busæus, S.J., folio, Mainz, 1604 [7]. Not included in these collections are his *Steganographia* (1531, etc.) [8], a work on cipher messages mistaken for magic conjurations, and his *Polygraphiæ* [9]. His letters (*Epistolarum familiarium libri duo*) [10] are included in the *Opera Historica*.

[3] Ferguson, *Bibliotheca Chemica*, Glasgow, 1906, ii, 471, says he died in 1519.

[4] On the life and writings of Trithemius may be consulted: Zedler, *Grosses Universal-Lexicon*, Leipzig and Halle, 1745, xlv, cols. 929–34; Jöcher, *Allgemeines Gelehrten Lexicon*, Leipzig, 1751, iv, 1326; N. Scheid, *Catholic Encyclopædia*, New York, 1912, xv, 62 (portrait); 'K.' in *Nouvelle Biographie Générale*, Paris, 1866, xlv, 644; Strunz, *Paracelsus*, Leipzig, 1903, 30 f.; lives of Trithemius are also contained in the collected editions of his works (see [6]) and in W. E. Heidel, *Trithemii .... Steganographia .... Conjvrationes Spiritvvm ...*., 4°, Nuremberg, 1721; Ferguson, *op. cit.*, gives a bibliography of sources (mostly secondary); L. Silbernagel, *Johannes Trithemius*, Landshut, 1868 (pp. 226 f., 244), says the alchemical works are spurious; a second edit., Regensburg, 1885, I have not seen; W. Schneegans, *Abt Trithemius und Kloster Sponheim*, Kreuznach, 1882 (on his scientific work, pp. 184 ff.).

[5] *Johannis Trithemii .... Primæ Partis Opera Historica. Secundæ Partis Chronica Insignia Dvo. I. Coenobii Hirsavgiensis .... II. Coenobii Spanhemiensis .... Accedunt Epistolæ eiusdem Familiares .... Cum Indice ...*., fol., Frankfurt, 1601.

[6] *Joannis Trithemij .... Tomus I.* [*Tomus II.*] *Annalium Hirsavgensivm .... Nunc primum .... è Manuscriptis Bibliothecæ Monasterij S. Galli publicæ luci datum ....* Typis ejusdem Monasterij S. Galli, fol., 2 vols., 1690. This edition includes some text of interest to us which is omitted in [5].

[7] An edition with supplement (*Paralipomena*) is said to have been published at Mainz in 1605. I have not read this large work, which seemed to contain nothing of interest to us.

[8] The first edition is said to have been in 2 vols. 8°, Lyons, with works of Agrippa etc.; the first edition I have seen is of Frankfurt and Darmstadt, 4°, 1606, *Steganographia .... Joanne Trithemio, Abbate Spanheimensi & Magiæ Naturalis Magistro perfectissimo*; for Heidel's edition see [3].

[9] *Polygraphiæ libri sex .... accessit Clavis*; sm. fol., *s. l.* [Oppenheim], 1518 (unpaged), and many later editions, *e. g.*, 8°, Argentinæ (Strasburg), 1600; French translation by Gabriel de Collonge, *Polygraphie*, 4°, Paris, 1561 and 1625.

[10] Haganovæ, 4°, 1536.

Many other works (including *Naturalium Quæstionum* in twenty books) are unpublished or lost.

Trithemius [11] emphasized that Albertus Magnus was a learned and saintly man, who ' scrutinised the depths of natural philosophy and learned to know wonders unheard of by others ', as a result of which he was unjustly regarded as a magician. Although not ignorant of natural magic, Albert had innocently acquired his knowledge by reading a great number of superstitious books, which is necessary if one is to be able to distinguish natural from illicit magic. Trithemius was for the same reason accused of being a magician. Bovillus (Charles de Bouelles, 1470 ?–1553), in a letter to Germanus de Ganay of 8 March, 1509, reports that he had seen the *Steganographia*, a large work which if published would be the wonder of the world [quod si vnq. publicatū fuerit (quod absit) totus mundus mirabitur]. He thought it contained Arabic, Hebrew, Chaldee and Greek names of spirits [12]. Trithemius [13] complained of charges brought against him by Bovillus, ' that rude ox ', and swore that he never carried out works of superstitious magic or entered the theatre of alchemy, nor directed the attention of his friars to such vanities. Naudé [14] and Heidel [15] acquit him of being a magician, astrologer or alchemist. Trithemius had read suspicious works [16] and he was acquainted with alchemy ; Cornelius Agrippa [17] says he conversed with Trithemius in the latter's cell at Würzburg on chemistry, magic and the Cabbala (in cenobio tuo apud Herbipolim aliquandiu conversatus, multa de chymicis, multa de magicis, multa de cabalisticis). This interest had the same effect as that of Albertus Magnus, in that several spurious works on alchemy were foisted on Trithemius [18].

[11] Quoted by Heidel, *Steganographia*, 1721, *Vita Trithemii*, 35.

[12] In *Que hoc volumine continētur. Liber de intellectu . . . . Epistole complures*, fol., Paris (Stephanus), 1510, fol. 172 *r*.

[13] *Annalium Hirsaugensium*, edit. St. Gall, 1690, ii, 288 ; ' In animam juro meam, quòd magiæ superstitiosæ operam dedi nunquam, neque theatrum Alchimiæ intravi, neque fratrum meum aliquis intendit hisce vanitatibus '.

[14] *Apologie pour tous les grands personnages qui ont esté faussement soupçonnez de magie*, La Haye, 1653, 505 f.

[15] *Op. cit.* [3], 56 f., in a section headed : ' Trithemium non fuisse Alchymistam, Astrologum et Magum '.

[16] In a letter from Cologne, 12 July, 1505, to Jacob of Mafeck, he thanks him for the gift of a Greek manuscript of the *Kyrannis*, which he says he values more than a gift of money. He quotes from it. *Epistol. familiar.*, 1536, 37.

[17] *De Occulta Philosophia*, fol., *s. l.* [Cologne], 1533, sign. aa iii ; Morley, *Cornelius Agrippa*, 1856, i, 217. The work was shown in 1510 to Trithemius, who advised Agrippa not to publish it.

[18] Hoefer, *Histoire de la Chimie*, Paris, 1866, i, 475 ; Kopp, *Die Alchemie in älterer und neuerer Zeit*, Heidelberg, 1886, i, 141, 226 ; both say the works are spurious, and Kopp emphasizes that Trithemius criticizes alchemy in his genuine works. Some titles of alchemical works attributed to Trithemius are :

(a) *Tractatulus III Chemicus Nobilis Joannis Trithemii . . . . ab quodam autore anonymo . . . . nunc primum in lucem editus*, in *Tractatus de Secretissimo Antiquorum*

Parallel to the story of Albert's magic garden [19] is a fable [20] that Trithemius offered to raise the spirit of the wife, Marie of Burgundy, of the Emperor Maximilian, and accomplished this in a lonely room in the presence of the Emperor and one courtier ; the Emperor recognized the spirit by a mole on the nape of the neck, but he was very displeased with Trithemius !

The unhealthy interest of religious orders in alchemy during the thirteenth century has already been authenticated by documents quoted in a previous paper [19], and another example may be added [21]. The chronicle of the Benedictine convent of Saint-Berthin, formerly Sithiu, for the year 1264 reports that the Abbot Gillebert, who was in high favour in Rome and was called ' Abbas Aureus ', was a famous alchemist. The chronicler, John of Ypres (Johannes Iperus, d. 1383), had himself seen a collection of the abbot's alchemical apparatus, and there were in the chapel four silver candlesticks which Gillebert

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Philosophorum Arcano, 8°, 1611 (B. Mus. 1033 e. 39). Lenglet du Fresnoy, iii, 316, mentions this, and says it appeared in Ripley's *Axiomata* and in *Theatrum Chemicum*, 1659, iv, 585–6, but the latter is a very short tract only.

(b) *Ein Büchlein des Hocherfahrnen Philosophi D. Iohannis Tritemii Abbat* : *An Pabst Clementem &c. De Lapide Philosophorum*, Halle, 1619, 45–154 (in an incomplete copy of a collection, B. Mus. 1143. *a*. 18 (3–5)).

(c) *Epistel von den drey Anfangen der natürlichen Kunst der Philosophen*, Magdeburg, 1602, q. by Schmieder, *Geschichte der Alchemie*, Halle, 1832, 237 ; Ferguson, ii, 329.

(d) *Güldenes Kleinod oder Schatzkästlein sein Unschätzbarkeit wegen vom Bruder Basilius Valentinus aus dem Lateinischen übersetzt*, Leipzig, 1782, q. by Schmieder, *op. cit.*, who says it is spurious.

(e) *De Septem Secvndeis, id est, intelligentijs, siue spiritibus Orbes post Deum mouentibus*, 8°, Cologne, 1567, q. by Lenglet du Fresnoy as an alchemical work, is not on alchemy at all.

(f) Gerhard Dorn, *De Spagirico Artificio Io. Trithemii*, in *Theatrum Chemicum*, 1659, i, 388, quotes Trithemius on the *Tabula Smaragdina*.

A spurious work on magic attributed to Trithemius is *Veterum Sophorum Sigilla & imagines magicae . . . . ex Ioan. Trithemii manuscripta erutae*, 1612, q. by Naudé, *op. cit.*, reprinted Herrenstadt, 1732.

A work mentioned by Hoefer, *op. cit.*, viz. *Curiositates regia* : *octo quæstiones jucundissimæ simul et utilissimæ a I. Trithemio, abbate S. Benedicto, propositæ et ab eodom solutæ*, Douai, n.d., as extremely rare (copy in Ste. Geneviève Library, Paris), is apparently the same as the *Liber octo quæstionum quas illi dissoluendas proposuit Maximilianus Cæsar*, sm. 8°, Cologne, 1534, in the British Museum (700. b. 38). It is not on alchemy.

[19] Partington, *Ambix*, 1937, **1**, 3 f.

[20] Zedler, *op. cit.*, col. 930.

[21] Martene and Durande, *Thesaurus novus anecdotorum complectans . . . . epistolas, diplomata*, etc., Paris, 1717, iii, 741. ' Pars X. De factis domini Gilleberti abbatis nostri.' The chronicler adds : ' Haec enim ars pulcra promittit & pauca donat . . . . nec umquam vidi qui attigerit ad opus verum quod satis est probabile ; nam hujus artis principia non propriè concordant cum principiis naturalibus '. He quotes Albertus Magnus, ' in libro suo, qui intitulatur *Semita recta* [see [19]], quem ipse de hac arte composuit ', to the effect that alchemical gold does not cure leprosy or gladden the heart, and alchemical iron is not attracted by a magnet, and he also refers to the prohibition of alchemy by the Pope John XXII.

had made from alchemical silver. In the time of the prior who followed him a candlestick was broken and was sent to a goldsmith for repair. In the fire, however, it melted to dross more rapidly than tin or lead, and disappeared (in igne positi non duraverunt, sed instantissime & citiùs stagno vel plumbo liquati formam argenti non retinuerunt ; sed ferè totaliter in cineres evanuerunt ; quare oportuit fieri novos).

The progress of alchemical studies among clerics in the fourteenth century is attested by Chaucer [22] ; in the fifteenth century we have some information from Trithemius [23]. He says the learned Joannes de Livania, who flourished in Trier in 1375, wrote against the prophecies of John of Rupecissa and three books against the vanities of alchemists (pulchrâ venustate decoratos) [24]. He also mentions that when Archbishop Cuno of Trier resigned in 1388 he left a great treasure, which his nephew and successor Werner diminished by buying books on alchemy and hiring many alchemists who worked for several years. It was believed, however, that Werner had buried great treasures of gold and silver, but these were sought in vain by John of Baden, the fourth archbishop after Werner. John also employed an alchemist, George of Croatia, for twelve years, after which the latter absconded to enter the service of Eberhardt, Duke of Würtemberg. Archbishop John was said to have wasted 30,000 florins on the art, but he denied this in the presence of Trithemius, blushing violently (erubescentiam forte pro mercade consecutus). His chamberlain Henry, a citizen of Cologne (civis Confluentinus), lost his whole fortune in alchemy and vanished, leaving his wife and family behind. Bernard, an abbot of Saxony who was a student of alchemy, left his monastery deeply in debt, and other clergy who sought the philosopher's stone were Andreas, Abbot of Bamberg, who wasted great sums ; a Carthusian prior of Nuremberg who worked five or six years (per annos quinque aut sex pro amore virgineæ meretricis Alchymiæ) ; and Melchior de Moka, bishop of Brixen [25]. Trithemius also refers to the activities of Franz von Sickingen, who had an operator called ' Georgius Sabellicus, Faustus iunior ' [26].

With these examples before him Trithemius was in a good position to form a judgment on the character of the alchemists, and several trenchant statements in his genuine works leave no doubt as to his attitude towards the matter.

[22] *Canon's Yeoman's Tale* ; *Canterbury Tales*, edit. Pollard, London, 1894, ii, 280 f., 287 f. ; Chaucer shows such a detailed acquaintance with the operations and technical terms of alchemy that he has been regarded as a disappointed practitioner of the ' cursèd craft ', and his statement that ' for al the good he spendeth ther-aboute he lesè shall, ther-of have I no doubte ' (lines 830 f.) may refer to his own experience ; J. M. Manley, *Some New Light on Chaucer*, London, 1926, 235 f. Chaucer appears among the English alchemists in Ashmole's *Theatrum Chemicum Britannicum*, London, 1652, 227 f.

[23] *Cf.* Thorndike, *History of Magic*, etc., New York, 1934, iii, 512 ; iv, 347.

[24] *Annalium Hirsaugensium*, St. Gall, 1690, ii, 267.

[25] *Ibid.*, 286 f.

[26] *Opera Historica*, edit. Freher, 1601, ii, 559.

In a letter of 24 August, 1505, to Germanus de Ganay [27] he says the alchemists are fools and disciples of apes, enemies of nature and despisers of heaven (alchimistis, quoniam fatui sunt et simearum discipuli, hostes naturæ et cœlestium contemptores). In his *Annals*, in criticizing John of Rupecissa (fl. 1354), he passes the following judgment on alchemy :

> ' Vixit his temporibus in humanis Joannes de Rupecissa Frater Ord. Minorum, qui multo tempore Alchimiæ deditus, tempus cum labore non satis utiliter consumpsit. Est autem Alchimia (ut more loquamur humano) casta meretrix quæ amatores plures habet, sed delusis omnibus in nullius unquam pervenit amplexus. Ex stultis facit insanos, ex divitibus pauperes, ex Philosophis fatuos, ex deceptis loquacissimos deceptores, qui cum nihil sciant, omnia se scire profitentur, cum sint pauperrimi, Crœsi divitias suis se daturos sequacibus pollicentur, quorum finis confusione plenus est ' [28].

In another place in the same work [29] he says :

> ' Dominam tamen Alchimiam in abditis se contenentem nec vidit, nec audivit. Quasdam tamen ancillulas in ergasterio vanitatis paulatim cœpit ex consuetudine habere familiares (quarum ista sunt nomina) : sophisticatio, deceptio, simulatio, falsitas, impossibilium præsumptio, spes vana, & plures quasdam alias, quarum mos est intrantibus in officinam illudere quas sequutus pulcherrimam atque castissimam se habere Dominam Alchimiam putavit, dum fœdissimis atque loco ejus suppositis abuteretur meretriculis, quæ nullis parcunt officinam vanitatis ingredientibus.'

Still more trenchant is the alchemical ' Rake's Progress ' quoted by Dr. Titley [30], the source of which has been lost to historians of chemistry for many years. In the form quoted by Dr. Titley it had been given by Kopp [31], who seems to have found it on the reverse of the title-page of the Second Supplement to Becher's *Physica Subterranea* [32]. A text somewhat different from that given by Becher had been quoted before by the learned Jesuit opponent of alchemy, Athanasius Kircher (1601–80) in his *Mundus Subterraneus* [33], where the reference to Trithemius is given. It is in the

[27] *Epistolarum familiarium*, 1536, 90–91 ; *De septem secundeis*, 1567, 62 ; *Opera Historica*, edit, Freher, 1601, ii, 472.

[28] *Annalium Hirsaugensium*, St. Gall, 1690, ii, 225, where he says of Rupecissa : ' scripsit in carcere . . . . De quinta Essentia 1. II. & alia plura in medicinis & Alchimia, vana potiùs quam utilia '.

[29] *Ibid.*, 288.

[30] *Ambix*, 1938, **1**, 169.

[31] *Geschichte der Chemie*, Brunswick, 1844, ii, 214 ; *Alchemie*, Heidelberg, 1886, i, 226, where the reference to Becher is given.

[32] Becher, *Supplementum secundum in Physicam Subterraneam. Theses Chymicæ veritatem et possibilitatem transmutationis metallorum in aurum evincentes*, 8°, Frankfurt, 1675.

[33] Fol., Rome, 1665, ii, 318.

Polygraphiæ[34], and, since the text is the same in both editions of the latter which I have been able to consult, I give it here :

> ' Alchimia a pluribus amatur, & casta est. Multas habet alchimia domesticas familiares, quæ dominam suam perpetua vigilantia custodiunt, seque eius nomine supponunt, ut eam conseruent à commercio tot importunè amantium tempore sempiterno intactam. Vanitas, fraus, dolositas, deceptio, sophisticatio, cupiditas, falsitas, confidentia mendax, stultitia, inopia, paupertas, desperatio, fuga, proscriptio, & mendicitas pedissequæ sunt alchimia, quæ dominam simulantes amatam eam inviolatam custodiant, & semetipsas illius quæsitoribus pecuniosis, avaris, cupidis, & fatuellis libenter prostituunt.'

[34] *Polygraphiæ*, lib. vi ; Oppenheim, 1518, fol. q 5 *verso* ; edit. Argentinæ (Zetzner), 1600, 598.

ALCHEMY UNDER JAMES IV OF SCOTLAND [1].

By John Read, Ph.D., M.A., Sc.D., F.R.S.

Most of the princely patrons of alchemy in mediæval times were animated by credulity and avarice, rather than by an intelligent interest in science; and the court astrologers and alchemists were charlatans who gained a precarious livelihood, and sometimes an untimely death, by imposing upon this credulity of their masters in the matter of gold-making, or multiplying.

Of the more intelligent princes, whose interest in alchemy was not solely mercenary, James IV of Scotland furnishes a worthy example. He had an active and inquiring mind, and sought to extend his knowledge by observation and experiment. His interests included medicine and surgery, physiology, alchemy, and even psychology.

In the realm of psychology, James's experimental *tour de force* dealt in a very direct way with the problem of that 'primitive tongue' which Ben Jonson, in a jocular mood, supposed to be High Dutch. Lindesay of Pitscottie gives an account [2] of this historic experiment, started in 1493:

> 'the king gart [caused] tak ane dum woman and pat hir in Inchekeytht [Inchkeith island in the Firth of Forth] and gaif hir tua zoung bairnes [two young children] in companie witht hir and gart furnische them of .... meit, drink, fyre and candell, claithis [clothes], witht all wther kynd of necessaris .... desyrand .... to knaw quhat langage thir bairnes wald speik quhene they came to lauchfull aige. Sum sayis they spak goode hebrew bot as to my self I knaw not bot be [except by] the authoris reherse [narration]'.

According to the canny Lindesay, James IV was 'weill leirnit in the art of mediecein and also ane cuning sorugenar' [3]. The generous monarch, in his eagerness to secure practical experience in surgery and dentistry, reversed the usual procedure, and paid a fee to his patients. Thus, an entry of 1491 in the accounts of the Lord High Treasurer of Scotland runs as follows: 'Item, to Domynico, to gif the King leve to lat him blud, xviijs.' That the King also indulged in dental practice is shown by an entry of 1511–12: 'Item, the

[1] Summary of a lecture delivered before the Society for the Study of Alchemy and Early Chemistry.

[2] R. Lindesay of Pitscottie, *The Historie and Cronicles of Scotland* (ed. Æ. J. G. Mackay), Scottish Text Society, 2 vols., Edinburgh and London, 1899, i, 233.

[3] *Ibid.*, p. 237.

ix day of Februar, to ane fallow, because the King pullit furtht his tootht, xiiij*s*.[4].

It is likely that James IV's excursions into alchemy were determined largely by his interest in medicine, because of the potent medicinal virtues which were ascribed at that time to the Philosopher's Stone. This, the ultimate goal of alchemy, viewed in the light of the doctrine of the unity of all things, was pictured not only as a transmuting agent for the perfecting of base metals into gold, but also as an infallible remedy for the ills of imperfect man.

The medicinal and rejuvenating effects sometimes ascribed to the Stone were perhaps inspired by the physiological action of that marvellous spirit of wine which was often regarded as the perfect solvent for the Stone, in the preparation of the Elixir of Life. 'The patient shall think he is no longer a man, but a spirit', wrote Isaac of Holland, referring to the rejuvenating action of the Stone, or Elixir. 'He shall feel as if he were nine days in Paradise, and living on its fruits.'

James IV's chief associate in his alchemical studies and experiments was a certain John Damian, an ingenious and personable foreigner who had been attracted to the Scottish court from either Italy or France. Damian included a practical knowledge of medicine and alchemy among his numerous accomplishments: 'in pottingry he wrocht grit pyne', wrote William Dunbar, referring to his prowess in the art of the apothecary. Under his inspiration and direction James established an alchemical laboratory at Stirling, in the Castle. Considerable sums of money were needed to sustain these activities, and Damian figures repeatedly in the contemporary accounts of the Lord High Treasurer of Scotland.

It appears from these accounts that, quite apart from the cost of his furnaces, apparatus and materials, and the wages of his 'ministers', an alchemist was an expensive adjunct to a mediæval court. Thus, in February 1501–2, 'Maister Johne' was provided with garments befitting his position, at a total cost[5] of £22 16*s*. The separate items were: a long damask gown lined with lambskin, £15 16*s*.: 'London scarlat to be tua [two] pair of hos', £3; and 'wellus [velvet] to be brekis [short hose]', £4. Among other disbursements made at this time on behoof of Maister Johne were 24*s*. for linen sheets, 18*s*. for a pair of blankets, and further sums for a Kentdale frieze and a tapestried bed. Moreover, beyond the running expenses of his researches, our 'Franch

[4] *Compota Thesaurariorum Regum Scotorum. Accounts of the Lord High Treasurer of Scotland*, 11 vols., Edinburgh, 1877–1916. Vol. i edited by T. Dickson, vols. ii–xi by Sir J. B. Paul. Vols. i–ix published by H.M. General Register House, vols. x and xi by H.M. Stationery Office. Vols. i–iv cover the period from 1473 to 1513, *i. e.*, up to the death of James IV.

[5] It is notably a matter of great difficulty to correlate the currencies of different eras. A multiplier of 3 or 4 may be applied in order to convey a rough idea of the modern equivalents of the costs set out in this paper. This index must be regarded as a tentative rather than a rigid factor.

leich ' drew frequent sums ' be the Kingis command ' for unspecified purposes : the total amount which he absorbed in this way during the six months following 26 August, 1503, exceeded £150.

At the end of this period a significant entry occurs in the accounts, under date 12 March, 1503–4 : ' Item, payit, be the Kingis command, to Bardus Altovite, Lumbard, for Maister Johne, the Franch medicinar, new maid Abbot of Tungland, quilk he aucht [owed] to the said Bardus, xxv*li* '. This brief note, in the Treasurer's prim and precise phraseology, records a dramatic move by the King, who had transmuted his alchemist into an abbot, in order to endow him with an emolument and provide him with the necessary leisure for his alchemical projects.

The new ecclesiastical dignitary preferred the smells of his laboratory to the odour of sanctity, and feared the effects of the laboratory smoke upon religious vestments which were far more costly than his alchemical garb ; for William Dunbar, the poet, who had cast longing eyes upon the vacant appointment at Tungland, in Galloway, wrote acidly of the Abbot [6] :

> ' Unto no mess pressit this prelat,
> For sound of sacring bell nor skellat . . . .
> On him come nowthir stole nor fannoun,
> Ffor smowking of the smydy.'

The Lord High Treasurer's accounts show that the new prelate was indeed very active during the next few years in the laboratory at Stirling Castle ; but it seems that the adequate leisure appertaining to his appointment was accompanied by a less adequate emolument. Such an inference may perhaps be drawn from a plaintive entry of 27 July, 1507 : ' Item, lent, be the Kingis command, to the Abbot of Tungland and can nocht be gottin fra him xxxiij*li.* vj*s.* viij*d.*'

The expenses incurred for the actual materials which Damian used for alchemical and medicinal purposes must have reached an impressive total, especially as many of them had to be fetched from abroad. For example, on 30 May, 1502, the ' Franch leich ' was given a sum of 300 French crowns, equivalent to £210 in Scots money, to cover the expenses of a visit to the Continent in connection with his work.

The accounts of the Lord High Treasurer of Scotland from 1501 to 1513 throw some interesting light upon the nature and cost of the specific materials which Damian and his associates used in their attempts to prepare the *quinta essencia*, or Quintessence. The precise information here recorded is indeed of exceptional value, since the alchemists were invariably secretive regarding their materials, apparatus, and running expenses. So pronounced was their reticence in these matters that a mere glance at a pictorial representation of an

[6] *The Poems of William Dunbar*, ed. J. Small, Scottish Text Society, 2 vols., Edinburgh and London, 1893, ii, 139–42.

alchemical interior by such an artist as Breughel, Stradanus, or Teniers often affords a better idea of the equipment and operations of these early laboratories than can be gathered from an exhaustive examination of dozens of written expositions of alchemy and its reputed achievements.

As a rule, the term ' quinta essencia ', as used in these accounts, may be taken to denote either the Philosopher's Stone or the related Elixir of Life ; but upon occasion it seems to be used as a slightly mocking nickname for Damian. According to the general dictates of alchemical theory, the ' primitive materials ' regarded as essential for the operations of the Great Work, or preparation of the Stone, were usually gold, silver, and quicksilver. All of these find a place in the accounts of James IV's treasurer.

Gold was provided chiefly in the form of gold coins, such as the four ' Hary nobles ' which were sent ' to the leich for to multiply ' on 3 March, 1501–2. The ' brint silvir ', costing 14*s.* an ounce, was possibly silver which had been purified for the Great Work by cupellation. Quicksilver was used in quantities which show that it was fairly easy to obtain, and that it played an important part in the operations. The 5 pounds entered on 20 February, 1502–3, cost 20*s.* ; and a further 25½ pounds was sent to Stirling, ' to mak quinta essencia thare ', about a month later.

Another material consumed in large quantities by the alchemists of Stirling appears in the accounts under the name of ' aqua vite '. This term, in Scotland, probably meant whisky at that time, since the Exchequer Rolls of 1494–5 show that a certain pioneer of the Scottish distilling industry, known as Friar John Cor, was supplied with eight bolls of malt for making aqua vitæ. The preparation of strong alcohol by the repeated distillation of wine and other fermented liquors was a well-known process at the beginning of the sixteenth century : thus, the title-page of Brunschwick's *Liber de arte Distillandi de Compositis* (Strassburg, 1507) [7] bears a woodcut illustrating the use of a water-cooled ' serpent ', or primitive fractionating column, for this purpose.

The physiological properties of strong alcohol made a great impression upon the early alchemists who handled and investigated it. ' The taste of it ', wrote the pseudo-Lully in his enthusiasm, ' exceedeth all other tastes, and the smell of it all other smells '. It was prepared from living material, capable of germination and growth ; moreover, it appeared to combine the properties of the opposed elements, fire and water, or sulphur and mercury [8]. Thus, spirit of wine which had reached ' myche hignes of glorificacioun ' by distillation ' unto a thousand times ' was identified by some of the alchemists with the Elixir of Life, quinta essencia, or ' mannys hevene '. The Abbot of

[7] The title-page is reproduced in E. Gildemeister and F. Hoffmann's *Die aetherischen Oele* (3rd edn., Leipzig, 1928, i, 45) : see also E. Kremer's English translation, *The Volatile Oils* (London, 1913, i, 41).

[8] In the era of phlogiston, alcohol was similarly regarded as a compound of phlogiston and water.

Tungland's interest in aqua vitæ is easily understandable by the student of alchemy, if not by others.

Although in the strange Scotland of James IV whisky must have been a rare drug reserved mainly for medicinal purposes, Damian and his collaborators were able to secure and find uses for surprisingly large amounts of it. An early entry of 10 March, 1502–3, records the application of ' aqua vite to the curyis [researches] of quinta essencia '. Later entries show that it was procurable in various strengths :

> ' Item [June 1508], to David, barbour, for vj quartis aqua vite thryis drawin quhilk yeid [went] to Strivelin ; ilk quart xij*s.* ; summa iij*li.* xij*s.*
> ' Item [June 1508] j galloun small aqua vite to the Abbot of Tungland, xxiiij*s.*'

The small aqua vitæ cost 6*s.* a quart, the ordinary 8*s.*, and the thrice-drawn (possibly known as ' mannys hevene ') 12*s.* Still another source of the magic fluid is recorded in an entry of 13 October 1507 : ' for ane punschioun of wyne to the Abbot of Tungland to mak quinta essencia, vj*li.* ' ; but whether this raw material was devoted wholly to the Great Work or partly to ' the refreshment of wearied Servants of Laboratories ' is not clear from the Treasurer's accounts.

Reliable data concerning the cost of specific and serious attempts to prepare the Philosopher's Stone are so exceedingly rare that it is of interest to summarise some of the information embodied in the accounts of the Lord High Treasurer of Scotland during the period of Damian's researches. The appended list gives, in contemporary Scots money (*cf.* footnote [5]), the prices of certain alchemical materials and apparatus used in Scotland between 1501 and 1508. Items marked with an asterisk are taken from painters' expenses, except sulphur, which was bought as an ingredient of gunpowder.

Prices of Alchemical Materials and Apparatus in Scotland, 1501–1508, in contemporary Scots Money.

	£	s.	d.	
Alchemists' attire :				
damask gown	15	16	0	
velvet short hose	4	0	0	
scarlet hose	1	10	0	
Alembic, silver, 10 ¾ oz. (bos hed to ane stellatour)	6	19	9	
Alum (allum)			7	lb.
Aqua vitæ (aqua vite) :				
small		6	0	quart.
ordinary		8	0	quart.
thrice-drawn		12	0	quart.
Bellows, small (bellisses)		1	0	
Cauldrons, 18 gallons	1	1	0	
*Cinnabar (synaper)		16	0	lb.

	£	s.	d.	
Flasks, large glass (gret flacatis)		4	0	
and		6	8	
Flasks, small glass (urinales)		2	0	
Glass, cakes of		5	0	
Gold	6	10	0	oz.
*Linseed oil (oly lingeat).....		8	0	quart.
Litharge (litargiri auri)		5	0	lb.
*Mastic (masticot)		4	0	lb.
Mortar, metal, 53 lbs.	3	9	0	
Mortar, brass, with pestle (brassin mortar with pestell)	1	0	0	
*Orpiment (orpement)		6	0	lb.
Pitchers, earthenware (pecharis)			4½	
and		1	3	
Pot, large earthenware (pottis of lame) ...		1	0	
Quicksilver (quyk silvir)		4	0	lb.
*Red lead (rede lede)		2	6	lb.
Sal ammoniac (sal aramomakle)	1	15	0	lb.
Saltpetre (sal-petir)			3	oz.
Silver (brint silvir)		14	0	oz.
Silver wrought		13	0	oz.
Sugar (succour)		1	6	lb.
*Sulphur (bryntstane)		8	0	stone.
Tin (fyne tyn)		1	2	lb.
*Verdigris (varngreis)		6	0	lb.
*Vermilion (vermeloun).....		6	0	lb.
Vinegar (vinakir)		4	0	gallon.
*White lead (quhit lede)		2	0	lb.

The materials and apparatus for the work in the Stirling laboratory were often supplied to Maister Alexander Ogilvy, also described as 'doctour', who was evidently an active participant in the operations. Another name which occurs frequently in the accounts is that of the Captain of Stirling Castle, Andrew Ayton. Caldwell, the keeper of the furnaces, received a wage of a shilling a day. These furnaces were in constant operation; fuel for heating them, and the wages of members of the laboratory staff who attended to the firing, etc., figure prominently in the accounts. Thus, on 'the penult day of March' in the year 1503 'ane boy that kepit the furnes fire, be the Kingis command' received 6*s.* 8*d.* The fuels mentioned are charcoal, wood, peat, and coal.

The Abbot's attempts to achieve the Stone were interrupted in 1507, as a result of another of his spectacular activities. In the quaint language of Bishop Lesley[9]: 'This Abbott tuik in hand to flie with wingis; and to that effect he causet mak ane pair of wingis of fedderis'. Equipped with these movable feathered wings, he took off from the lofty battlements of Stirling Castle for a flight to Paris; 'bot shortlie he fell to the ground and brak his

[9] J. Lesley, *The History of Scotland from 1436 to 1561*, Edinburgh, 1830, 76.

thee bane'. Nothing daunted, the courageous experimenter ascribed his downfall 'to that thair was sum hen fedderis in the wingis', which yearned and coveted the midden and not the skies: if the wings had been made entirely of eagles' feathers, they would have exerted a natural tendency to soar into the heavens!

William Dunbar celebrated this incident with unnecessary gusto in a satirical poem entitled 'The Fenyeit Freir of Tungland, how he fell in the myre fleand to Turkiland'. There is some soul of poetry in all good alchemists and chemists, who will therefore appreciate the force, if not the language, of Dunbar's spirited lines:

'Me thocht seir fassonis he assailyeit,
To mak the quintessance, and failyeit;
And quhen he saw that nocht availyeit,
A fedrem on he tuke,
And schupe in Turky for to fle . . . .

He schewre his feddreme that was schene,
And slippit owt of it full clene,
And in a myre, up to the ene,
Amang the glar did glyd.'

Notwithstanding such contemporary jibes, and the later condemnation of Damian as an arch-imposter, anybody who has peered over the battlements of Stirling Castle will agree that the man of metals was also a man of mettle, endowed with the courage of his convictions, and deserving of the lucky star which had let him down with nothing worse than a broken thigh-bone. To evaluate the achievements of mediæval experimentalists is even more difficult than to express mediæval prices of labour and materials in modern currencies. Judged by the standards of his day and generation, Damian appears to have been an enterprising and enlightened exponent of the experimental method in science.

The unsuccessful court alchemist often received short shrift from his disappointed patron; but the broad-minded Scottish king, comprehending Damian's sincerity of purpose, and knowing from his own experience that experiments 'gang aft agley', treated him with characteristic generosity. By this time, indeed, the King had admitted his alchemist-in-chief to a degree of friendship which must have appealed particularly to a specialist in the art of multiplying gold. They played cards, dice, and other games together, and a scrutiny of the Lord High Treasurer's accounts shows that the stakes were wont to run unusually high when the King played with the Abbot. Contests of this kind seem to have been particularly frequent during the Abbot's convalescence, whilst the broken 'thee bane' was healing. The entries do not necessarily indicate that the King never won, since the accounts deal only with disbursements; but the frequent debit items suggest that he lost steadily and royally.

Judging from the Treasurer's records, work proceeded apace in the Stirling laboratory during the first half of 1508. Then, on 8 September 1508, ' Damian, Abbot of Tungland, obtained from the King a licence to pass out of the realm and remain in what place he pleases at the study, or any lawful occupation during the space of five years '. The object of the Abbot's travels is not specified, but it may be inferred that he had planned a visit to some of the Continental centres of alchemical activity, in order to gather new inspiration and to purchase manuscripts, books, and materials for the continuance of the Great Work.

Damian returned to Scotland in 1512 ; but the direction of the work on the quinta essencia seems to have remained in other hands, as the later entries suggest :

> ' Quinta Essencia [1512] : Item, to Maister Alexander Ogilvy, for his ordinar expens fra the x day of September last bipast to the xiij day of August . . . . as his compt beris ', £214 4*s*.

A supplementary item ' to the said Maister Alexander, for drogry [drugs] and werkmannis wagis to the Quintessence ', from 13 August to 16 July, amounted to £41 6*s*. 10*d*.

> ' Item, the xiii day of Maij [1513] to Robert Maklellane, that makis the quinta essencia in the Castell of Striveling, be the Kingis command, vij*li*.'

This new alchemist is referred to elsewhere as ' Robert McCllane, the man that makis the watter in Striveling to the quintessence '. Finally, on 5 August, 1513, there are two entries running as follows :

> ' deliverit to the Constable of Striveling xlij*li*. allem [alum], to put in the quinta essencia, price tharof, xl*s*. . . . Item, to Valentyne McLellane that suld mak the quinta essencia, lvj*s*.'

Little more than a month after the date of this last entry, on 9 September 1513, the interest of the Scottish crown in alchemy came to an untimely end, with the death of James IV on the tragic field of Flodden. It was a century and a half before this interest in science found a rebirth in two of James's distant descendants—Prince Rupert of Bavaria, and King Charles II.

PETROLEUM AND BITUMEN IN ANTIQUITY.

By R. J. Forbes, D.Sc.

In earlier publications we discussed the data to be found in literature on the history of bitumen (39), subsequently examined several old samples of bitumen (40), and later the information obtained was summed up (42).

It was to be foreseen that, the available facts and texts being so incomplete, the answer to a great many problems could be merely guessed or, for want of data, would for the time being have to remain unsolved. What the technologist wished to know was how bitumen had been used, and it was precisely on this point that adequate information was lacking and that only a rough idea could be formed. It was, therefore, especially with the object of finding references to the preparation and application of mastic asphalt and asphalt mastic in antiquity that we again searched the texts. Although we have not been able to find a complete answer to our questions, we have discovered a few facts supplementing and correcting our former views [1]. In this work we were greatly assisted by Professor Dr. N. Schneider (Luxemburg), who collected many ancient Sumerian texts for the author; we have also to acknowledge our indebtedness to the Oriental Institute (University of Chicago), especially to Dr. F. W. Geers, for supplying texts of more recent date from Mesopotamia and for many valuable comments on earlier assumptions made, and also to Van Proosdÿ (Leiden). Furthermore, Mr. M. Mercier had the happy thought of devoting a morning session of the Economic Section of the Second World Petroleum Congress at Paris (June 1937) to *Archéologie et Histoire du Pétrole*, at which many reports submitted—(43), (54), (66), (81), (94), (95), (96)—were discussed by a circle of technologists and archæologists. Many valuable facts are recorded in these reports which will be discussed in these pages.

One of the problems raised in Paris was that old controversial question as to whether *the ancient Egyptians were acquainted with petroleum and bitumen* and whether these materials were generally used in Egypt. Séguin (94) had submitted an essay on the subject which gave rise to some discussion. One of the things he has tried to show is that the frequent mention of mysterious, earth-fed fire or fires which water will not quench reflects memories of, or acquaintance with, petroleum and natural gases in Egypt. An assumption

[1] It should be remembered when reading some of the suggestions for the interpretation of philological evidence that they are given by a chemist and have only a tentative character.

of that kind cannot be accepted off-hand. Fire plays so eminent a part in the religion and magic art of nearly all ancient peoples that there is no justification for connecting *a priori* the many references in their texts and legends to mysterious fires (often of magic, *i. e.* chastening, power) with the burning natural gases or like phenomena known to petroleum geology. Flinders Petrie's theory (originally Fessenden's), quoted by Séguin, to the effect that the Egyptians originally came from the Caucasus and had memories of the natural gases and petroleum still burning there, was not only rejected by the archæologists gathered together in Paris, but was declared years ago by Petrie himself to be untenable. The vague knowledge that at one time bitumen was in some way connected with the preservation of mummies in Egypt is so exaggerated and stressed in most works on bitumen that this is often the only use of bitumen in antiquity the layman remembers. There is something to be said, therefore, for reverting to our earlier statement (42) and explaining what we know of this problem.

Every investigator must realize that the old Egyptian texts give him little to go by. Although we have access to many medical texts, including several describing the process of mummification, as a rule the enumeration of the ingredients used is not clear enough to enable us to decide what substances were meant. So-called technical texts are not infrequently merely lists or prescriptions which make identification impossible, and so we have only gradually penetrated into the secrets of ancient Egyptian pharmacology.

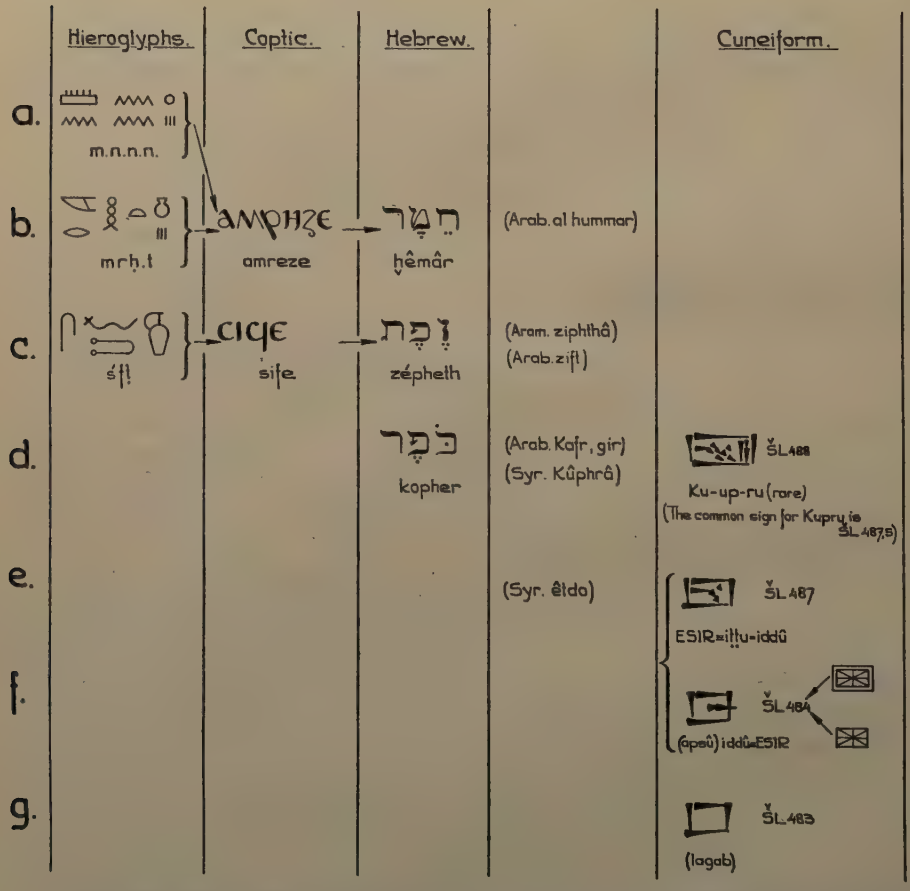
Ever since the hieroglyphics were first deciphered three terms have been taken by some investigators to stand for bitumen or bituminous materials, and translations in this sense and quotations in technical literature are often based on them. We shall now inquire whether there is any justification for this.

First of all there is the word *sift* (fig. 1, *c*). The Erman-Grapow dictionary (p. 160[1]) gives *Salböl* (ointment) for *śft* (the more modern spelling, as no certainty exists about the vowels in Egyptian words). Certainly, as far as we are able to judge by the texts, this was the most common meaning of the word before the Hellenistic period (300 B.C.). This word *sift* occurs even in the old pyramid texts, namely, in the list of ointments (e. g. *Pyr.* (51)). It holds a prominent place in the religious literature as one of the seven (later eight to ten) ' holy ' oils. Reutter, who always took this material to be bitumen, assumed it, on the strength of prescriptions, to be present in several ointments prepared with these holy oils, and says that he identified it in such ointments, a statement which Lucas (69) rightly doubts. In this connexion it is certainly an oil, for it is mentioned in one breath with other oils, such as cedar-oil, etc. A determinative denoting ' oils ' is often added to the word *sift* in the texts, as, for instance, in a very early one dating from the reign of Sahure, in which *sift-oil* is donated as a burial gift (89) ; also in a later text of the time of Pepi II (97) ; both, therefore, date from before 2000 B.C.

In several of what are known as the Later Egyptian texts (after 1580) Thotmes III mentions *sift-oil* as one of the tributes he brought back from his campaigns in Syria (9) ; and a pitcher full of *sift-oil* is mentioned in a somewhat later text of Rameses III (8).

Finally, when discussing a mummification ritual of the sacred Apis bulls (text between 250 and 100 B.C.), Spiegelberg comes to the conclusion that

Fig. 1 Nomenclature of Bituminous Materials in Antiquity.



' Here *sift* still clearly stands for an oil ; it has not yet acquired the meaning of *sife* derived from the Coptic (fig. 1, *c*) *resin, pitch.* It is not used for filling, but as an ointment ' (100).

In some texts there appears to be a certain connection with cedar-wood, and occasionally it has not been necessary to translate *sift* vaguely as *Salboel*, but more determinately as *Cedar-oil pitch.* Thus Sethe (98) says :

'Besides soda, cedar-pitch played an important part, though usually described as bitumen by the modernists. As long ago as in the Old Kingdom it was mentioned in connection with burial in a coffin made of cedar-wood from Lebanon. In the well-known *Admonitions of an Egyptian Sage* (about 2000 B.C.) the interruption of sea-borne traffic with Byblos is lamented because "neither the cedar for the interment of the mummies, nor its pitch (*śft*), comes to Egypt" (*Admon.*, iii, 7–8).'

FIG. 2.

Classification of Bituminous Substances and their Nomenclature in Antiquity.

Genus	Species	Member	Description	Latin	Greek	Sumerian	Akkadian	Hebrew	Egyptian	Arabic Turkish, etc.	Sanskrit
I Bitumens	a) Petroleums	All crude oils	"Asphaltic crude oil" (containing no crystallizable paraffine) is most suitable for the production of petroleum asphalts	Bitumen liquidum (maltha ?) (2)	naphtha (maltha ?)	esir-ne esir ni-gis-esir = ni-kur-ra =	naptu šaman-iddt (14) šaman-šad (15)	nepht naft		alnaft neft (seyali) naptik (Pers.)	
	b) Native mineral waxes	Ozokerite, etc.	Paraffinaceous material, called ceresine when refined		(ampelitis?)	Probably unknown				neftgil kir ?	
	c) Native Asphalts	Asphalt	Pure or fairly pure; less than 10% associated mineral matter	maltha } bitumen	maltha } asphaltos (6)	(10) (8) esir-lah } esir	iddu, ittû it-tu-u	zephet ?	mnnn (mrh. Kr) (28)	seyali (21) mûmyâ zift, ziphl	(jatu ?) Probably unknown
		Rockasphalt	Large percentage (upto 95%) of sand, sandstone, limestone, clay or shale	(lapis bituminis)	pissa (5) asphaltos	(9) esir-harsag esir-a-ba-al igi-esir (11)		hêmâr (19)		chemal humar qasal (22)	silâ jatu (25) asmajâtam jatu (26)
	d) Asphaltites	Gilsonite Glance pitch, etc	Higher fusing point than asphalts derived from petroleum soluble.	(gagates?)	ampelitis (27)						
II Pyro-bitumens	a) Asphaltic Pyrobitumens	Elaterite Wurtzelite, etc.	Infusible and Insoluble Generally pure, derived from petroleum	Occuring practically only in America, unknown in Antiquity							
	b) Non-asphaltic Pyrobitumens	Peat	Pure or fairly pure. Derived from vegetable matter Gradual transition from peat to lignite to coal. (1)	Only vaguely known in later Roman times.							
		Lignite		gagates (3)							
		Bituminous coal		lapis thracius	spinos						
		Anthracite coal		carbo (4)	anthrax (7)		pêntu (?)	peḥâm (?) (20)			
III Pyrogeneous Distillates	a) Pyrogeneous asphalts	Different types of paraffine wax	Produced from petroleum distillates	Modern development of petroleum industry, certainly unknown in Antiquity.							
	b) Tars	Pine tar (Hardwood tar)	Produced by destructive distillation of wood, peat, coal, etc.	(serum picis) Pix liquida	(pisselaion) pissa hygra						
		Peat tar Coal tar		Produced since about 1790 only, certainly unknown in Antiquity							
IV Pyrogeneous Residues	a) Pyrogeneous asphalts	Different types of petroleum asphalt (asphaltic bitumen)	Produced as the residue of asphaltic crude oil distillations	Probably rarely produced in Antiquity as the evaporation residue of asphaltic crude oils							
				bitumen ?	asphaltos ?	esir ?	iddu ?	unknown?	?		
	b) Pitches	Pine tar pitch Wood tar pitch	Residues of the distillation or evaporation of the corresponding tars.	pix	pisso, pitta.	esir-lah (12) (kunin, ?) (17)	qatranu (18) Kupru Ku-pur	zephet kopher	(śft ?) ? (29)	(ziphl ?) kir kafr	jatu (24)
		Coal tar pitch etc.		Coal – Tar – Pitch is of course unknown in Antiquity.							
(1) The most common fuel is of course wood or charcoal. Charcoal is often confused with coal and also called carbo (Lat.) = anthrax (Gr) = pêntu (Akkad) = peḥâm (Hebr)											
V Artificial Mastics:	Prepared by mixing suitable (usually pure) bitumen with sand, limestone, lime and or fibrous materials and the like			not used ?	not used ?	esir-é-a (13) esir-gul-gul esir-sun-sun esir-apin (16)	?	unknown?	unknown	ghir (23) Kir (Kafr)	unknown ?

(2) Names like petroleum, kerosine, etc. are modern terms.
(3) Used by later writers to denote fossil coal, jet and similar substances
(4) In the Middle Ages terms like carbo fossilis, lithantrace are invented.
(5) In the Attic dialect "pitt asphaltos"; often used for fossil resins ampelitis etc.
(6) No Akkadian equivalent known, probably derived from σφαλλω (Lidell-Scott).
(7) Used by Aristotle for "carbuncle.
(8) This refers to the refined product, other synonyms are esir-UD, esír-par and esir-gir. The crude wet product is called esir-è-a or esir-UD-DU-a, in medical texts the terms A-GAR-GAR-AN-ID or A-GAR-GAR-DINGIR-ID.
(9) Lit "mountain asphalt" esír-a-ba-al denotes the same product.
(10) Certain bitumen GIR is known from Assyrian lawbooks, but its properties are not defined.
(11) The term igi-esír may denote some kind of épuré.
(12) It is still uncertain whether some kind of asphaltic bitumen was prepared in Ancient Mesopotamia.
(13) Lit. "house asphalt".
(14) Lit. "oil of asphalt".
(15) Lit. "oil of the mountain."
(16) Three terms denoting mastics used for irrigatio apparatus like waterwheels, etc.
(17) Kunin is generally used to indicate a ship coated with bitumen.
(18) Pitch of fir or pine.
(19) Said to be a synonym of "Kafr al Yahoed" (Arab.) = "Jew's pitch".
(20) Commonly used for charcoal; "gaḥelet" meaning the glowing coal.
(21) Term restricted to the fresh fluid or semi-fluid bitumen.
(22) Used for the older bitumen, hardenend and contaminated with sand found near the seepages.
(23) The crude native mastic prepared with sand, lime etc
(24) Use for resin, gum or pitch.
(25) Lit. "stone pitch".
(26) Lit. "pitch generated by stone"
(27) Lit. "vine-earth", also called "pharmakitis".
(28) Copt amrêze = ΑΜΡΗΖΕ, said to come from Phoenicia, Coptos and "Punt"
(29) Copt. ΛΑΜΣΑΤΤ, CIQE

Sift is given the meaning of *turpentine* (?) in a translation of the great Ebers medical papyrus (31).

All that can be gathered from the texts regarding the meaning of *sift* is, therefore, that it often came from Syria and was usually an oil, but that it can occasionally be translated as *Cedar-pitch*. Cedar-pitch had been known for a very long time in Egypt, as Menghin's discoveries in prehistoric graves at Ma'adi (78) prove. There is nothing to show that it was bitumen. Certainly, in the later Coptic it means resin or pitch, as does also the Hebrew word *zepheth*, which is probably akin to *sift*. Whether this is synonymous with *bitumen* we do not yet know. *Sift* is also closely connected with the process of mummification.

Another old Egyptian word that has been thought to be related to bitumen is *merhi* (fig. 1, *b*). Erman-Grapow translated *mrḥ.t* (p. 684[4]) as *Salboel, Oel*, deriving it from a verb *Wrh* meaning *anoint*, a derivation which Brugsch also gives (10, 679).

About fifty years ago Maspéro devoted much study to this word (72). In papyrus no. 5158 at the Louvre and papyrus no. 3 in the Boulacq Museum, he found descriptions of the process of mummification in which different kinds of *merhi* are mentioned and came to the conclusion that the word stood for oils used *pour y faire dissoudre toutes sortes de matières qui la rendent épaisse et pâteuse* (to dissolve all kinds of substances which make it thick and pasty). In some instances he assumes that it means *poix* (*huile* ?) *extrait des arbres croissant sur les montagnes du Liban* (pitch [oil ?] extracted from the trees growing on the heights of Lebanon).

Loret subjected that study to close criticism (67), and came to the conclusion that ' the derivatives of *merhi* do not generally denote bitumen ; the word *merhi* is always translated as *oil* in the general sense of ointment. He suggests, nevertheless, that this word has the same meaning as *mennen*, which we shall discuss, so that, according to his reasoning, it would denote bitumen after all.

Merhi is a word of frequent occurrence in the Pyramid texts (*Pyr.*, 754, 879, 2071–2073), where it signifies an oil used on a large scale, but it is not made clear whether it is of animal or of vegetable origin. Chassinat (15) quotes examples, ranging over the entire period of Egyptian history up to the Roman period, in which this word is used to denote an oil, certainly not a grease. Budge translates it as *unguent, grease, fat of any kind*, and Ebers as *oil, animal fat, in any event liquid or unctuous substance.*

At the end of his study Chassinat adds that in some cases the word may have some other signification, viz., *dans les références liturgiques suivant le cas de l'huile, de la graisse, de la poix ou du bitume* (*malthe, poix minérale*) (in liturgical references, oil, grease, pitch or bitumen [mineral pitch] as the case may be). There is, at all events, nothing to justify the translation of this word by bitumen unless it is clear from the context that that is the meaning,

or in those cases where, in a bilingual text, it is made equivalent to terms definitely known to mean bitumen. For example, a late text calls it an equivalent of the Coptic *amreze*, which means bitumen (10, vi, 4).

The third term, *mennen* (fig. 1, *a*), has more right to be translated as *bitumen*. Brugsch gave it (11, 506) with reference to a text in the Pap. Rhind (vi, 1), in which mention is made of boiling (melting ?) bitumen. Erman-Grapow (p. 659[9]) translates it as bitumen. Maspéro (72) points out to us that *mennen* was imported into Egypt from Phœnicia, Thabor or Punt (S. Arabia ?) *via* Koptos, and thinks it stands for a kind of resin. Loret (67) has disputed this and thinks bitumen is meant. He admits that it comes from Syria or Phœnicia to Egypt and in some cases from Punt *via* Koptos, but bases his argument upon the known text of Dioscorides (i, 99) in which he dwells on the use of bitumen for mummification. He also points out that the word *mennen* is often written with a suffix (so-called determinative) in the hieroglyphic texts, denoting granular or pulverized materials. He moreover cites the recipe for a scented ointment, which speaks of *triturating and sifting mennen*. It is also mentioned together with soda for the treatment of the swathes of mummies. Various quantities of *mennen* are mentioned in the great Harris Papyrus, *e. g.*, 30 kilogrammes (xxxiii, B. 12), 32 baskets (lxiv, C. 12) and 30 kg. or 10 baskets (lxx, B. 14–15), in the last-mentioned case cited in one breath with quantities of certain resins. Yet Loret still doubts his own identification of *mennen* with bitumen.

It is also mentioned in a medical excerpt of the Ebers Papyrus (54, 19) which Ebbell translated (33). It contains a prescription to triturate orpiment together with bitumen (*mennen*) and to place this mixture on heated bricks. It claims that inhalation of the vapours will relieve a cough !

We are inclined to infer from all these data that *mennen* stands for the glance-pitch known especially in Syria (42). This material greatly resembles the resins so well known to the Egyptians, as far as appearance and melting point are concerned, and they therefore perhaps mistook it for a resin. This is not unlikely, seeing that *mennen* was used for all the treatments involved in mummification for which resins were also employed, and so perhaps Maspéro and Loret are both right in the end. One thing is certain, namely, that *mennen* is explicitly made equivalent to the Coptic *amreze* in later texts and that it came from those parts where deposits of glance-pitch are known to be, which deposits seem to have been mined very early (38).

So even though a few words in the texts may sometimes signify bitumen, and one almost certainly does, we have reason to believe, on other grounds as well, that bitumen was not an important factor in Egyptian life.

The Egyptians never availed themselves of the opportunity of collecting crude oil from the seepages on the coast of the Red Sea and producing bitumen from it. Recent investigations at the Djebel Zeit have shown that the seepages were not worked until Roman times, and then only on a modest scale. Near

the sea coast there are pits 3 metres deep containing many remains of the earthenware utensils with which the oil was skimmed off the pools (91).

Modern forms of analysis have also failed to produce much proof of the use of bitumen in Egypt.

It was not used as a paint (113, vol. ii, 287). Fragrant and preservative balsams, resins, etc., were generally used for mummification. Extensive research by Lucas has shown that wood-tar pitch has been used since Ptolemaic times (78), and in later work he has not been able to cite the use of bitumen ; on the contrary, he disproved Reutter's analyses which identified bitumen (69) Spielmann tried to detect bitumen spectrographically, but came to the conclusion that ' bitumen and resin are present in relatively low percentages, the Egyptians undoubtedly having used wood-tar pitch as a diluent.' One has perhaps been tempted to think that bitumen was used because, since the Twelfth Dynasty, the mummies have been dark, sometimes black. Without proof to the contrary, it must for the time being be regarded as certain that bitumen was not used to any appreciable extent before the Ptolemaic period, and even then only for second-rate processes of mummification. We share Coremans' opinion that ' it is generally admitted that bitumens, or like products, were " frequently " used for ancient embalming processes. This does not apply to Egypt, where resins, almost to the exclusion of anything else, were used for the purpose. It was not until the Ptolemaic period that bituminous materials were perhaps " very rarely " used. Only a very marked similarity in the appearance of these two groups of substances could have given rise to this regrettable confusion ' (22).

Seeing that from Ptolemaic times a certain amount of bitumen was exported from Palestine and Syria to Egypt, it is very strange that although the numerous deposits of bitumen in various forms were known even in antiquity (42), the bitumen does not seem to have been used in the countries of their origin themselves. Albright (2) points out that a certain amount of bitumen has been found in various places. Thus Duncan found a ' considerable deposit of lumps of asphalt ' in Ophel, in Canaanite Jerusalem, dating from the Third Millennium, and in Tell Beit Mirsim nearly every stratum contains lumps of crude bitumen (from the Dead Sea ?). These deposits most commonly date from the Second Millennium, but some from the Second Iron Age, *i. e.*, 600–100 B.C., also. Albright thinks that the bitumen may possible have been used for making furniture, but that any traces of it there may have been have disappeared with the remains of the wood. In view of the properties of bitumen as preserved in very old samples (42), we think that this is unlikely. It would undoubtedly serve a good purpose if the bitumen of these deposits were subjected to analysis.

The same applies to Syria where, actually, the only find is a pendant from Byblos in which pearls and coloured precious stones are fixed in gold filigree

with bitumen (29). Strangely enough, we know of no texts from these parts which make any mention of bitumen ; not even the recently discovered Ras Shamra texts make any reference to it. A layer of material, identified by Claris (17) as bitumen, has been found at the bottom of a sarcophagus at Byblos, but the analysis is not very convincing. Séguin (95) felt justified in assuming that the Phœnicians traded in bitumen and took it even to Carthage, where it was used for embalming the dead. Without further proof, based on analyses, we feel that these assumptions should be treated with reserve, particularly as Séguin's data are largely derived from Mover's book on the Phœnicians which, in the light of more recent archæological discoveries, has become somewhat antiquated. Nor is it an established fact that, as Moret [2] states, bodies in Canaan were wrapped in bitumen-coated mats and then burned on funeral piles, as they were in Babylon.

We shall now discuss the latest data on the oldest history of bitumen in Mesopotamia, the only country where bitumen was really used on a large scale in very ancient times. We now know, partly thanks to the geological exploration of Mesopotamia in the last few years, that numerous forms of deposits of bituminous products occur at the surface of the earth there. These deposits were also known in former times, and it is because the earliest inhabitants of Mesopotamia, the Sumerians, were keenly interested in the manifestations of nature that records of these phenomena have come down to us in the writings of their time. We have enumerated these deposits before (42), but would here recall those in the surroundings of Susa which are mentioned by De Morgan in *DP*, i, 29.

Natural gases have always played a certain part in history, although their importance is sometimes exaggerated in technical treatises. These gas-wells were especially important in Iran because of the part played by fire in Iranian religion (53). They were particularly awe-inspiring because, as the old name, *varishnak*, implies, they *needed no food* (52). Down to classical times we find traces of the part played in religious cults by burning natural gases. They are, for instance, depicted as burning near Apollo's Shrine (21) on coins of Apollonia, near the present Selenizza (Albania).

Natural gases were known in Mesopotamia, but had nothing to do with religious cults ; they are, however, mentioned in the omen-literature, to which we shall revert presently. There is also a passage (90), in the annals of King Tukulti Ninurta II (889–884 B.C.), describing gas-wells near Hit as follows :

> ' Opposite Id (Hit), close to the sources of bitumen (*kupru*), I camped at the place where the voice of the gods issueth from the *Ušmeta* rocks.'

These *Ušmeta* or *Ussipta* rocks are gypsum strata seamed with bitumen and sulphur deposits ; the gases, mixed with bitumen and water, forcing

[2] *Histoire de l'Orient*, Paris, 1926, 299.

their way through these gypsum strata to funnel-shaped fissures in the earth's surface, make a roaring noise, which was taken for the voices of the gods in the underworld and, therefore, for an oracle (92). Similar deposits from which roaring gas issues are found in the surroundings of Kirkuk, where they are accordingly called *kirkuk baba* or *abu geger*, which means ' the father of sound '.

Seepages of asphaltic crude oil are found in many places in Mesopotamia, particularly along the the present frontier between Iraq and Iran at the foot of the mountains. Many texts refer to these seepages, and a number of terms are found for this black, viscous oil. It has sometimes been supposed in literature that these oils were used for lighting ; we quoted some publications on this before (42). Although it is not entirely out of the question that it was so used, the thick sulphurous oil is certainly less suited for illumination than the olive-oil generally used, and will also have given less light No texts giving information on its use in lamps have so far been found. What we did point out (42) was that bitumen may have been prepared from these oils by inspissation, although there are no proofs for this either, other than those from classical times. However, these oil seepages do play a part in the omen-literature, as we shall presently see.

One of the best-known terms for petroleum is the Akkadian word *naptu* (Hebr., *naṭpik* ; Greek, *νάφθα* ; Arabic, *alnaft*). The source of this word has long been a matter of doubt. Many investigators have taken it for an Iranian word. This is Darmesteter's opinion (23), for instance, who derives *naphtha* from an old Iranian word *nab* (to wet), which he then assumes to have passed into the Persian language of the Avesta's as *napta* ; the latter word is then supposed to have given rise in Mesopotamia to the Akkadian word *naptu*.

At the Paris Congress Herzfeld not only defended this theory, but even quoted from the myths of old Iran (54) to support it. Although the word naphtha is not mentioned anywhere in these myths, a hymn to the goddess of the Earth (Mas'udi, iv, p. 74, 2°) speaks of an eternal fire, which needs no feeding and is to be found on the southern coast of the Caspian Sea. Another hymn mentions a fire—a symbol for Iran—burning in the ocean. This is a legend which also has come down to us from Indian lore. Further, the Iranian myths have a water-god, Apam-Napat, who has much in common with the god Neptune. Attempts have been made to relate the names of these two gods to the word *naphtha*, or at any rate to the original stem *nab* (Meillet). We cannot go any further into the philological aspect of this problem (on which expert opinion is still divided), but may point out that, as the word *naphtha* has not been expressly mentioned in these myths, the connexion should not be assumed to exist as a mattter of course. These mythical fires may be nothing more nor less than different forms of the sacred fire which plays such an important part in Iranian religious cult. Supernatural qualities or magic powers were ascribed to these fires, but there is nothing to show that they were mentally connected with burning natural gases or

petroleum. Fires invested with magic power occur in the legends of practically every people in whose religious cult fire plays a part. However, we possess other proofs of the existence of the word *naptu* in Mesopotamia, before there can be any question of an Iranian text. Its derivation from *napâṭu*, *nabâṭu* (to flare up, to blaze) is in perfect agreement with Akkadian habits of word formation and proves that here the word *naptu* was not formed for a special application, but described the natural phenomenon, like other terms for bitumens in Mesopotamia.

We moreover possess a number of old texts containing this word. The most important is an old Babylonian text (*CT*, iii, 2^5) which, according to Hunger [3], dates from about 2000 B.C. and in which *naptu* is used in connection with oracles. We would further mention four texts, of which, admittedly, we only have a later version, but which certainly draw on older originals. In one of them a certain person pays 1/6 shekel of silver for *naphtha* (*Vorderas. Schriftdenkm.*, vi, 228^3). Two omen-texts speak of a *flood of naphtha* (*CT*, xxxix, 21^{156}) or a *naphtha fire* in a certain part of the town (*CT*, xxxix, 10^{26}) as ill omens. In a fourth text it says: 'If in a certain place of the land naphtha oozes out, that country will walk in widowhood' (*CT*, xxxix, 10 a^5).

These few lines are probably sufficient to rule out any but an Akkadian origin for this word and to show that it spread from Mesopotamia both to Iran and westward. That is why we cannot agree with Séguin, who at one time thought he had to do with a Hebrew original (66). In *Macc.*, II, i, 36, naphtha is mentioned in direct connection with the 'Persians'. A curious point about all these texts is that *naphtha* still stands for crude oil. It was not until after the introduction of distillation that the word *naphtha* gradually came to mean *gasoline*.

The other terms for the asphaltic crude oil are directly related to the bitumen which can be prepared from it in such large quantities, a relation, therefore, of which the Ancients were already fully aware.

The term *šaman-iddî*, meaning literally *oil of bitumen*, has been mentioned before (42). *Šaman-šadî* (mountain oil) is a term that also occurs. But even older names are known to us. The Sumerian term for the former is *IÀ-GIŠ-ESIR* (*CT*, xxxix, 19, 121), the latter is called *IÀ-KUR-RA* (*AM*, 18, 3, 3) (*BBR*, 41, 17). Mention is also made of *ESIR-NE* (or ge_9, *ŠL*, 172, 18) (literally 'fire bitumen') —(7), (77, no. 11542)—which probably refers to burning natural gases or, perhaps, to crude oil.

Of much more importance to the Sumerians, the oldest inhabitants of Mesopotamia, were the solid and semi-solid bitumens, and this is clearly shown by their nomenclature, which covers a variety of names for grades of bitumens. At the same time it is evident by this nomenclature that bitumen was mainly obtained from seepages. True, rock asphalts and asphaltites were known and sometimes used, but in production and economic importance they were

[3] Hunger, Becherwahrsagung, *Leipziger Semitische Studien*, Leipzig, 1903, i, 80.

far behind the other products. But the Sumerians seem to connect definitely '*bitumen*' and (subterranean) *water*. One has only to consider fig. 1, *c*, which is descended from the oldest cuneiform sign for *ESIR* (bitumen), to see that the latter conclusion is justified. Of the two signs used for *ESIR*, fig. 1, *f*, occurs invariably in the oldest texts, but is represented in the later texts by fig. 1, *e*, which more particularly means 'bitumen'. However, both characters are composite signs or ideograms and go back to the basic pictograph *LAGAB* (fig. 1, *g*) according to Deimel (25), which originally meant 'cask', and was later on also used for 'surround, shut off, etc.' By combining it with other signs the two ideograms for *ESIR* were formed. Thus the oldest sign is taken to be a combination of *LAGAB*+*ḪAL*, a combination which we do know from the oldest pictographs (24) in the form given in the figure, but which, in cuneiform, had degenerated to *ŠL*, 484. This symbol not only has the general meaning of 'ocean, fresh water, abyss', but is also used for 'river, canal, source,' and similar concepts. This has something to do with the Sumerian conception of our world. They conceived of it as floating on a large freshwater lake, the '*Apsû*', from which rivers and wells received their water and from which also rose all kinds of demons to ensnare mankind.

Hence a symbol was used for bitumen indicating that this substance, like river-springs and well-water, oozes from the depths of the Earth. Very often this symbol is found combined with the symbol for water, accentuating, as it were, the idea of bitumen being a substance issuing from the freshwater abyss, or as Deimel (25) expresses it: '*Wie das Süsswasser quillt in Mesopotamien das Bitumen aus dem Apsû hervor*' (*ŠL*, 457). (In Mesopotamia bitumen wells up, like fresh water, out of the Apsû).

We have to wait until we get to the late Sumerian texts to find a separate sign (fig. 1, *e*), a compound of *LAGAB* and *NUMEN*, which we do not know from old Sumerian texts (*ŠL*, 487), but which is generally used for *ESIR*. The later Babylonians and Assyrians, who spoke a Semitic language (Akkadian), but use the old Sumerian signs, to which, consequently, they imparted a phonetic value, compiled many vocabularies, a kind of Sumerian-Akkadian dictionaries. From these dictionaries it is quite clear that this late-Sumerian sign is used for the Akkadian words *iddû* and *kupru*, both meaning bitumen. We shall revert to these terms later on—(12), (25), (27), (28).

In the texts bitumen is written in two ways, viz., *ŠL*, 487 preceded by the symbol for water; this combination is represented by *ESIR*. The symbol *ŠL* 487 also occurs alone, and is then represented by *ESÍR* (or $esir_2$). We shall adopt this (Continental) spelling in our subsequent pages.

This relation between bitumen and the freshwater abyss also appears from other examples, *e.g.*, in magic texts, in which bitumen is the seat or the symbol of powerful evil spirits, spirits rising from the Apsû to do harm to man.

In several vocabularies bitumen is related to other products deposited by the water on the banks of the rivers. The Sumerians were acute observers

of natural phenomena around them, and the peculiar structure of their language enabled them to express the qualities (especially visual ones) of rocks, minerals, plants and animals, etc., in their nomenclature. Thus, they used the same root-word for a group of objects, *e.g.*, rocks, which they thought were related, and differentiated each member of such a group by a suffix expressing its characteristic properties. Thus we see the products from the rivers (Sumerian, *ÍD*) grouped as follows (according to Campbell Thompson in his *Dict. of Assyr. Chemistry and Geology*) :

(Sumerian)	(Akkadian).	
KI-A-(AN)-ÍD	*kibritu.*	black crude sulphur.
ÚḪ-(AN)-ÍD		yellow sulphur.
BÁ-BA-ZA-(AN)-ÍD	*pappasi*	gypsum from the Euphrates.
A-GAR-GAR-(AN)-ÍD / (*ESIR*)	(*iddû, kupru* ?)	bitumen, pitch.

In a similar way various bitumens are distinguished by suffixes to the root *ESIR*, to which we shall revert. The *A-GAR-GAR-(AN)-ÍD* occurs usually in medical texts and, according to Campbell Thompson, seems to be the crude wet form of bitumen obtained from the seepages.

As to the word *ESIR*, Haupt (*Beitrage zur Assyriologie*, **10**, ii, 141) has pointed out that it stands by a common vocalization for a stem *ASIR*, lit. *illuminating water* (?) (2). Besides, *ESIR* or *iddû* is mentioned positively with special reference to the river god *ÍD* (*BBR*, xxvii, 11).

All this is given tentatively as additional proof that seepages in the vicinity of Hit played a leading part in the production of bitumen in ancient Mesopotamia (1). The present town of Hit is often mentioned in Sumerian literature as Duddul (Duldul, Dudul) or Idu (1), (60) ; later on the Greeks refer to *Is*. The word Duddul is assumed to be derived from *DUL* (well), and Idu (*I-TU*) seems to be connected with *ÍD* (river).

This town being the principal production centre of bitumen, its later Akkadian name *iddû* was given to bitumen (85), so that the present name Hit may be considered as being derived from the Sumerian name. This *iddû*, also written *iṭṭû* or *ittû* (76), (77), therefore first indicated the product from the seepages ; later on it was used in a more general sense.

If we want to define more narrowly the different kinds of *ESIR* occurring in Sumerian literature, we must not, like Forrer (44), start exclusively from the question as to whether these different kinds are measured or sold by weight or by volume, as this reasoning may lead to wrong conclusions. It is far better to ascertain in the first place for what purposes the kinds of *ESIR* mentioned in the texts were used, taking into account at the same time whether they were sold by weight or by volume, and, of course, not neglecting the price mentioned for the various grades. The so-called Period of The Third Dynasty of Ur (*ca.* 2400–2300 B.C.) Ur III, provides much information about these prices, enabling us to arrive at an average price. We have calculated these prices

in shekels (Sum. *GÍN*) (*ca.* 8·5 g. of silver) per ton; in the absence of exact data by which to fix an index figure for these early times, these prices may be considered only as relative values, but this is all we need for our purpose.

It is permissible to draw conclusions from the Sumerian nomenclature directly, provided they be confirmed by the texts concerning applications, as the translation for the various names is by no means firmly established in all cases. A point which is naturally confusing to anyone not acquainted with the Sumerian language is the fact that various scholars pick out different values for one cuneiform sign; thus their translations show different terms which are in reality the same. We will give the terms as found in the papers cited in each case.

Let us first take the group of *natural asphalts*. Those obtained from seepages were, of course, of the utmost importance.

ESIR-LAḪ or *ESIR-UD* (*UD, PAR* (see below), and *LAḪ* are indicated by the same ideogram) seems to be the natural asphalt from the seepages, which in purity and freeness from ash approaches present-day asphaltic bitumen. Only small amounts of occluded water have to be removed from it. We are inclined to infer from the texts at our disposal that *ESIR-LAḪ* is this purified bitumen, which, therefore, in point of properties, corresponds to the asphaltic bitumen obtained from crude oil by inspissation, or from rock-asphalt by melting under certain conditions.

In the Ur III period we find many lists of large quantities of *ESIR-LAḪ* expressed in weight or volume, in quantities varying between 4950 and 20 kg. and between 8500 and 1089 litres (average *ca.* 2900 kg.); the price for quantities by weight and volume is the same, *i. e.*, roughly, 3·5 shekels per ton. One text even speaks of a tribute of 280 tons of *ESIR-LAḪ* to be paid to the king of Ur by the town of Girsu (*CT*, vii, 21 *a*). This bitumen is frequently mentioned in connection with brick-work (*inter alia* ' for the house of the Grand Vizier ')—(46), (87)—and with shipbuilding (45) (see also Strabo, xv, 1). Another text of the same period tells us that five ships laden with *ESIR-LAḪ* have been despatched to Ur.

The term *ESÍR-PAR* is also mentioned (6), but as *PAR* is one of the values of the ideogram *UD*, this is identical with the above grades. Our final conclusion is, therefore, that translations of texts mention the following different readings of the same cuneiform signs for the *purified bitumen* from the pools of Hit:

(1) *ESIR-LAḪ*,
(2) *ESIR-UD*,
(3) *ESÍR-PAR*.

For the crude impure product of the pools we already mentioned the terms *A-GAR-GAR-(AN)-ÍD* or *A-GAR-GAR-(dingir)-ÍD*, which seems to be used in medical texts in particular. Besides this term, however, *ESIR-UD-DU-A*, *ESIR-È-A* (Delitzsch (28), p. 348, *b*) is also used. This addition *È—A* (*ŠL*, 579, 458) means, according to Thureau Dangin, *qui sort, qui jaillit* (which emerges

from, springs from), so that we are here clearly concerned with the crude bitumen which oozes up near Hit. It is identified by several scholars with *kupru* (77, no. 8970) (46, vol. v) (*ŠL*, 487, 5). This kind of bitumen is mentioned in medical texts (*AM*, 38, 6, 7 ; *AM*, 13, 4, 4 ; *AM*, 93, 1, 11); (*CT*, xxiii, 22, 44) and seems to have been used for the seams of ships. Hence, the *crude natural asphalt* is called

(1) *ESIR-È(UD-DU)-A,*

(2) *A-GAR-GAR-(AN)-(dingir)-ÍD.*

Several terms are also known for *rock-asphalts*, the principal being :

ESÍR-ḪURSAG (56) (46, vol. v, no. 755).

This word *ḪURSAG* means ' mountain', perhaps more correctly mountain-range, in contradistinction to *KUR*, mountain. Obviously, therefore, rock-asphalt is meant in this case. Gudea, the priestly ruler of Lagas (*ca.* 2400 B.C.) had it brought from the mountains of Magda. A quantity of 109 tons (?) is inscribed on the plaque bearing his image. It remains to be seen whether this is the exact quantity, or whether it does not rather stand for the whole consignment of bitumen, gypsum, etc., as the other texts of the slightly later Ur III period mention only smaller quantities, such as 7200 and 840 kilogrammes.

The other terms for rock-asphalt and like products were

ESÍR-A-BA-AL-ḪURSAG,

and

ESÍR-A-BA-AL.

It is not clear as to what the termination *A-BA-AL* (*ŠL*, 579) really signifies. Possibly it means that the crude rock-asphalt boiled with water yields bitumen, but so far no account of this technique has been found in old writings. In Barton's opinion (6) it means (?) *drawn or dipped from a well.* Maybe, however, bitumen was obtained from this rock-asphalt by the very ancient process of *destillatio per descensum* (dripping) (also see *ŠL*, 9, 18), as we have surmised before (42).

Like the rock-asphalt *ESÍR-ḪURSAG*, this rock-asphalt was sold by weight. Amounts like 606, 1515, 91, 45 kilogrammes and 55·3 tons (?) are mentioned on tablets of the Ur III period, so on the whole for smaller quantities than of the other group of bitumens, although the price is roughly the same, namely, 4·1 shekels per ton—(109), (87), (46, vol. ii, no. 755). This bitumen was used for the building of houses and terraces.

It was by no means only Gudea who obtained this bitumen from the mountains, for Sargon also imported rock-asphalt from Kimaš (Elam, the mountainous district along the present frontier between Iraq and Iran), and Ibi Sin had it brought from the region of Magda.

There was another product, akin to rock-asphalt, known by the name of *IGI-ESÍR*. This also came from the mountains (109) and was sold by weight—(37), (46, vol. v), (87), (*ŠL*, 449, 224). The texts of the Ur III period record only small amounts of 75 to 5 kilogrammes, an average of 40 kg., but the price is appreciably higher than that of the grades hitherto discussed, viz., 10·4 shekels per ton or more (87). Thureau Dangin gives the word

ESÍR-IGI-ENGUR

in Gudea's big inscription (109). He assigns to this word the same meaning as *KUNIN* (*ŠL*, 487, 5) which, in turn, is identical with *kupru* and, as *pars pro toto*, is used for a ship caulked with bitumen or bituminous mastic.

In view of the small quantities and high price, it may be assumed that the product in question is a bitumen (*épuré*) prepared by melting down rock-asphalt. The relatively slender demand for it may be explained firstly by the importation of large amounts of *ESIR-LAḪ* and, secondly, by the low yield and high prices of fuel.

To sum up, then, the following names have been found in translated texts of *rock-asphalt* :

(1) *ESÍR-ḪURSAG*,
(2) *ESÍR-A-BA-AL*,

and *IGI-ESÍR* for *refined rock-asphalt* (épuré ?).

The names of other kinds of bitumen clearly express the use to which they were put. The product mentioned most often is *ESÍR-É-A*, which we identified with bituminous mastic in an earlier publication (42). Forrer questions this identification ; he points out that, as this product is always referred to by volume, it must have been liquid. Moreover, he does not seem to distinguish the signs *ESÍR-É-A* from the *ESIR-È-A* already mentioned (44). *É* is the sign for house (*ŠL*, 487, 3), *ESÍR-É-A* is always mentioned in connection with buildings and brick-work (' for Urnammu's libation table ' ; ' for Gimil-Sin's house ' ; ' for the new palace ', etc.) (' for a gypsum container '), with caulking ships, waterproofing baskets, wicker, mats and the like—(*RTC*, 307, r. 11, 15) (46, vol. v, nos. 6784, 6982, 6892) (*CT*, v ; *Br.M.* 17752). No fewer than 77 texts of the Ur III period mention this product ; the amounts range from a few kilogrammes to 3500 kg., an average of 452 kg. These amounts are usually given by volume (46), (37). This does not prove that the material was fluid, least of all if we remember that the liquid mastic mixture was poured into ' loaves ' or baskets. We have had occasion before to examine various mastics composed of *ESIR-LAḪ*, fillers and fibrous material. When these were poured into the proper baskets or moulds, cakes were formed of a certain weight and volume. A sample originating from ancient Ur (42) still clearly bore the marks of the basket in which it had been packed. The price of this material was considerably higher—at an average of 18 shekels per ton (21 shekels at a somewhat earlier date)—than that of the other kinds, a further proof that

it is *not* the crude bitumen taken from the pools. Are we to assume that, fuel being very costly, it was the practice to mix the mastic on the site to avoid the double heating required for ready-mixed mastic ? No wonder Fish says that this mastic was dearer than dates or barley (37) ! This high price was also no doubt responsible for the fact that very much smaller quantities of bitumen in this form were used than of the raw material for mastic. The translated texts mention other kinds of mastic as well, one of which was called *ESÍR-GUL-GUL* (or *SÚN-SÚN*), the determinative of which term refers to machinery for irrigation ; the word is found in a text at the Louvre (*TC*, v, 7, col. i, 1, 3) and others (16). Apparently this product was also used for caulking ships. *ESÍR-APIN* (or *ENGUR*) is mentioned for a similar use. This *APIN* (*ŠL*, 56, 3) stands for sowing-plough, dredger and other apparatus used for irrigational purposes. This grade of *ESÍR* is also mentioned in connection with shipbuilding. The texts mention small amounts of 300 to 5 kilogrammes, but no prices (6).

The analyses of old samples, recorded on an earlier occcasion, also go to prove that various kinds of mastic were made. They showed that the mortars for brick-work contained on an average 35 per cent. of bitumen, and the mastic asphalt or asphalt mastic of floors and thresholds on an average 25 per cent,. a difference which, considering the number of samples examined, can scarcely be regarded as fortuitous.

An object is referred to in some texts under the name of *GIRRA*, and is said to be made of bitumen ((46), vol. i, 1451, 1, 2) (*CT*, v, 38, 213 ff.) (prices in (87) 121, 1, 12). Forrer relates this word—to our mind erroneously—with the present Arabic word *qir*. The texts should be scrutinized again by experts. Perhaps, as the price seems to indicate, *ESIR-GIR* (*UD*) is actually meant.

A special kind of bitumen also occurs in Assyrian statute laws (30), i. e., GIR_4 (*ŠL*, 430, 2, also see *ŠL*, 461), which, apparently, was imported from the north. Deimel mentions that the word was used in connection with furnaces for the melting of asphalt, pitch, etc. By Assyrian law some delinquents subjected to corporal punishment had, in addition, a jar of molten GIR_4 poured over their heads. A similar punishment was meted out in the Hana district (59), (111).

The following expressions are also interesting with regard to the use of bitumen :

The term *ESIR-ŠUB-BA* occurs in some texts of the Ur III period in connexion with house-doors and various objects, not yet clearly defined, made of reeds and rushes. This indubitably means ' coating with bitumen '. Delitzsch (27, p. 267) translates this as ' malaxer du goudron ', which certainly does not fit in these texts. Deimel and Meissner give approximately the same interpretation (77, no. 1681) ; Burrows (13, no. 48, ii, 1) shares our view.

It is interesting to note that three Ur III texts speak of a *ḪUM ESIR*, a mortar for bitumen ; but, unfortunately, they do not define the kind of bitumen. It is very probably rock-asphalt, pulverized for further treatment.

The number of grades of bitumen mentioned in the later Akkadian texts is limited to two. We used, certainly, to think *amâru* (79) was recognizable as a word for bitumen that might be the prototype of the Hebraic *hêmâr*, but closer study of the text proved that this was not so.

The word *iddû* is written with the symbol *ESIR*. As we have already contended, the word is probably connected with the name of the city, Hit, and first, therefore, stood for the soft, sometimes moist, product of the pools (77, no. 8970), but was afterwards used in a more general sense.

The second term, *kupru*, was usually represented by the symbol for *ESÍR*. It is related to a root *kpr*, which means to coat, and is used as a rule for harder bitumen or mastic. There are two other signs (fig. 1, *f*) which are read as *kupru*; the first is mentioned by Deimel (*ŠL*, 488) and Delitzsch (27, p. 375, ii), the second by Barenton (4) and Delitzsch (27, p. 36), and both are made equivalent to *ESIR*. So although a difference undoubtedly exists between these two kinds, as is apparent from several texts in which they occur side by side (104), this distinction is not always meticulously observed, especially in the later texts. The nomenclature suffered from the same carelessness in antiquity as in modern publications. As a rule *iddû* is rendered by *asphalt*, *bitumen*, etc., in translations, and *kupru* by *poix*, *Erdpech*, *pitch*, by which at least the difference in hardness is to some extent indicated.

The fact that so little bitumen was used in Assyria is remarkable, yet understandable. If we take the inscriptions left by various Assyrian kings we find the following:

Adad-Nirâri built his quay wall in Assur with bitumen in about 1300 B.C. (33). Upwards of four centuries later Tukulti-Ninurta II visited the seepages at Hit (90). In about 800 B.C., under King Adad Nirâri III, the governor, Bêl-harrân-bêl-usur, had many imprecations inscribed on his monument against any who should damage that work or cover it with bitumen. Sennacherib (71) built walls of limestone slabs with bitumen and Esarhaddon used brick and mastic for the foundations of his temple (*Beiträge zur Assyriologie*, **3**, 323, col. 5, l. 22).

The fact that bitumen is not discovered in excavated parts of that country explains the paucity of references to it in Assyrian texts. The preference for stone for building purposes in these districts and scarcity of suitable sources of bitumen in Assyria may easily account for its virtual absence. There is no mention of bitumen in the elaborate correspondence of the Assyrian merchants in Asia Minor, in the Hittite empire. Nor, indeed, were any traces of bitumen found during the excavations carried out in that area (*e. g.*, by the Oriental Institution at Alishar). Contrary to Séguin (95), experts inform us that there is no term for bitumen in the Hittite texts.

The very frequent use made of bitumen in Neo-Babylonian times in the south is all the more striking, but logical. Many inscriptions by Nabopolassar, Nebuchadnezzar, Neriglissar and Nabonidus mention both *iddû* and *kupru* (64),

(102), (103), in quantities up to 15 tons for the applications we have already discussed (42). Up to Persian times (Cambyses) the texts cite large quantities of bitumen (104), although by that time its use was fast diminishing. As these later texts do not appear to contain any particulars of technical interest and are accessible to all who wish to study them in the publications cited, we shall not discuss them all here. There are, however, a few general statements that are of sufficient interest to be mentioned. One letter from the ancient town of Uruk (18) states that *wine and bitumen will not go up the river in ships at the same time*. Another letter shows that there is a local shortage of bitumen, and somebody writes, not without exaggeration : " Concerning ½ *še* (23 milligrams) of bitumen for the fifth time I have written to you and you do not send it. Find me ½ *še* and send it ! ' (*Amer. J. Sem. Lang. Lit.* **32**, no. 84). Another letter complains in a similar strain (106)).

What interests us more, however, is the development and history of the use of bituminous mastic ; but, unfortunately, little positive knowledge is available. In most ancient periods the mortar was undoubtedly often a mixture of loam and chopped straw or reeds, bitumen, and filler and fibrous materials (42) in a composition remaining unchanged for centuries, with only slight variations for certain applications of different natures, such as mortar (35 per cent.) and asphalt mastic (35 per cent. of bitumen). This mastic appears so early in Tello, Ur and Uruk that Watelin said : *The use of bitumen is characteristic of antiquity* (114). This mastic was, moreover, used in Tello as sealing-wax, and statues were cut out of it (58), (84). Curiously enough, the mastic from Susa in Persia, which Berthelot analysed, has the same bitumen content (28 per cent.) (*DP*, xii, 20, 62, and 162) (20, ii, 807). The bituminous mortar or mastic then remains practically unchanged until the later Neo-Babylonian age when, particularly under King Nabonidus, almost pure bitumen was used for mortar (51). In Persian times the use of bitumen in all its forms fell completely into the background except for caulking ships. This has been proved again by Mercier, who published an excellent analysis of the mortar of the palace at Ctesiphon (81), a mortar often, but erroneously, said to contain bitumen. A short time ago Thureau Dangin published the translation of an interesting clay tablet (108) on the use of mastic, in which is calculated the amount of bitumen required for the bituminous mastic coating of a floor of a certain area.

Finally, King Hammurabi's code of law (*ca.* 1875 B.C.) gives an interesting comparison between the cost of coating with bituminous mastic and that of other work. Par. 228 of that code states that a house may cost 2 shekels of silver per Sar (*i. e.*, 35·3 sq. m.) base, a sum equal to what may be charged, according to Par. 234, for caulking with mastic a boat of 7½ cub. m. capacity.

As yet we have found no information in the available texts as to how the mastic was prepared or applied.

Bitumen also holds a prominent place in medicine. We have a few prescriptions (*AM*, 18, 3, 3 ; 73, 11, 8) in which crude oil (*IÀ-KUR-RA*) appears, and it is even used for anointing (*BBR*, 41, 17). But there are far more prescriptions for the use of bitumen in solid forms. Thus, mixed with sulphur and other substances, it is recommended for fumigation (*AM*, 78, 10, 4) and for the treatment of sores on hands or feet (*AM*, 15, 3, r.7) (*AM*, 70, 3, 1). Bitumen (*iddû*) fluxed with oil is prescribed for inflamed eyes (*AM*, 38, 6, 7). A mixture of beer and bitumen is suggested as a cure for some ailments (*AM*, 15, 3) (*AM*, 73, 1, 7). In describing the symptoms of a certain disease it is stated that the body becomes *as black as bitumen* (*KARI*, no. 473, 10), It is stated in one curious text that certain diseases can be cured by making the patient stand on bitumen (*kupru*) (*AM*, 90, 1).

In classical antiquity the bitumen found near the Ararat, or, according to some (47), that of the Djebel Djudi (Djudi Dagh) to the south-west of the Vân Sea, was credited with special healing power. Legend had it that the Ark had landed there, and that the bitumen collected from the rocks there had even greater cleansing power than that which had always been attributed to bitumen from all sources (47). It was also made into amulets.

Bitumen plays a double, rather contradictory, part in magic. On the one hand it is used to keep out evil spirits (*kupru*, *AM*, 93 11) ; on the other, the black substance is regarded as the power of evil (35), and *ESIR* is the symbol for, or actually is, the substance in which the demon *Ašakku* chiefly elects to reside. Bitumen holds an important place in many magic formulæ or rites. Images of the persons or objects to be bewitched were cut out of bitumen and, after the proper incantations, were buried near the victims. In a recently published collection of incantations (75) there is mention of *casting off a spell caused by an image made of bitumen* (*iddû*) (ii, 148–159) and *casting off a spell caused by means of a plastered bitumen image* (*iddû*) (ii, 181–205). In another text (*CT*, xvi, 22, 304) instructions are given to bury an image made of bitumen under the victim's front door after pronouncing the proper charm.

Another rite demands that the effigy of the victim shall be sacrificed to the fire demon (so, shall be burned). The materials to be used are enumerated with great precision, bitumen once again appearing frequently. This form of sorcery was very general in classical antiquity. For instance, in love enchantments the hay or straw torch or the laurel branch used for the spell is ignited with asphalt.

It was a very common habit in ancient days to coat door posts with bitumen or wood-tar pitch during certain festivals, particularly the Anthesteria, with the object of keeping out spirits.

Bitumen recurs again and again in the magic formulæ themselves, and citation of its special qualites is intended to make the formula recognizable to the invoked demons. For instance, a witch calls up the spirits as follows : *Like asphalt and pitch which come out of the depth* (*KARI*, no. 473, obv. 9),

or casts a spell on the victim in the following words: *As bitumen holds a ship, so I hold you and will not let you go* (*KARI*, no. 69, r). To illustrate the evil of witches, it is stated in another text that their spells render the victims as powerless as if *their mouth and ears were stopped with bitumen* (*CT*, xvii, 25, 26).

The phenomena observed in the neighbourhood of oil or bitumen deposits were put to good use for soothsaying. Examples were quoted when we discussed the term *naptu*. One text (*CT*, xxxix, 19, 121) (7) runs as follows: 'If there are agglomerations like petroleum or sesame oil borne hither and thither on the surface of the water, *mūšgārru* or disease will lay hold of the land.' Another says: 'If a pit opens in fallow land and burning bitumen appears, the land will be destroyed' (*CT*, xxxix, 22, 10). Sorcerers also augured by the shapes formed when bitumen or crude oil was poured out into a basin or beaker of water. One text dealing with this form of augury (*CT*, iii, 2, 5) says: 'If when I pour naphtha on water it has the appearance of asphalt, that means fate, the sick man will die.'

Finally, we should not forget the part still played in many of the Apollo shrines of classical times by burning natural gases and other manifestations observed wherever bitumen is found (Strabo, vii, 5, 8) (21).

There is little to add to the various applications of bitumen which we summed up before (42).

The use of bitumen as a cement for various costly gems in mosaics or inlaid work is one which has aways attracted attention and which is mentioned and illustrated in most manuals on bitumen. Friezes, consisting of white stone, mother-of-pearl, lapis lazuli or red stone laid in bitumen, sometimes placed in a copper frame, were made as early as the al Ubaid period (*i. e.*, before 3000 B.C.). This technique enjoyed long popularity, and numerous examples have come down to us from the Third Millennium—(116), (49), (62), (63). Bitumen is also used for holding gold or other beads (20), fixing knives in their hafts (Susa, (74)), and waterproofing porous material (*DP*, i, 66).

There was another application of bitumen which was far more common than is generally thought. The art was apparently understood of beating thin metal bands round sculptured cores of bitumen or mastic. The metal foil was made by hammering the metal out on flat stones and was then moulded round beads of wood or bitumen. This is how they made the golden horns of the bulls' heads found in Ur, to which we may assign the date of 2800 B.C. (50). The same technique is evident in the copper bulls of al Ubaid (118). Copper foil was hammered on to a wooden skeleton coated with bitumen. Sometimes, too, a cast-metal object was filled with a core of mastic. Such work is seen in the early cast-copper objects of Lagas and Tello (88), (51), and the same technique was applied in the north (Nineveh) (86, vol. i, 367). It was even done in Egypt apparently; at least Gsell (48) mentions a bronze Egyptian

statue (XIX or XX Dynasty, *ca.* 1000 B.C.) in the British Museum still containing a core of bitumen and sand reinforced by a piece of iron.

Bitumen, in the form of natural asphalt or mastic, played an important part in applied art. These two kinds of bitumen were easy to handle, and the results obtained by the Sumerian artists with this material are to be seen in the Louvre, for instance. It is a striking fact that the sculptural work done by the Sumerians in natural stone in the Third Millennium gives little hint of the artistic talent displayed in their plastic work with easily managed materials like the bitumen compositions mentioned or the wax core of an object cast in metal. This is quite comprehensible for, natural stone in Mesopotamia being very costly on account of its having to come from the mountains far away, they could have had but little opportunity of practising their art.

Finally, bitumen was put to curious use in warfare. Bitumen or mastic had long been used for the making of primitive bludgeons or dagger-hafts, as it still is by the Arabs in Northern Syria. During the excavations of Dura Europas, which was besieged and laid in ruins in 256 A.D. by the Persian king Sapor, corridors were found under the old walls (82). After the passages had been dug, the stays were burned with burning faggots, straw, bitumen and sulphur so that the collapse of the passages should make a breach in the wall. Hero of Byzantium stated that wood soaked in bitumen or crude oil was used to set fire to the stays, and the discovery of jars of bitumen bears him out.

This exhausts the accessible texts and facts relating to the oldest history of bitumen. Several problems have been tackled along technical lines, and attention has been drawn to those problems of technical interest that are still unsolved. It is now for philologists and archæologists to utilize our material and amplify it.

Abbreviations.

AM	R. Campbell Thompson, ' Assyrian Medical Texts ' (105).
BBR	Zimmern (119).
CT	' Cuneiform Texts from Babylonian Tablets in the British Museum ' (London).
DP	' Mémoires de la Délégation en Perse ' (Paris).
KARI.....	' Keilschrifttexte Assurs Religiösen Inhalts.'
Pyr.....	C. H. Sethe, ' Die altaegyptischen Pyramidentexte ', Leipzig, 1908–22, 4 vols.
ŠL	Deimel (25).

Bibliography.

(1) Albright, W. F. From Jerusalem to Baghdad down the Euphrates. *Bulletin American Schools Oriental Research*, 1926, **21**, 21.

(2) Albright, W. F. *Classical Weekly*, 1937, **31**, no. 2.

(3) Albright, W. F. *American Journal of Semitic Languages*, 1918, **35**, 165.

(4) Barenton, H. de. 'De l'origine des langues', Paris, 1932, i, 293.
(5) Barton, G. A. 'Archæology and the Bible', Philadelphia, 1927, p. 337.
(6) Barton, G. A. On Binding-reeds, Bitumen and other Commodities in Ancient Babylonia. *Journal American Oriental Society*, 1926, **46**, 297–302.
(7) Boissier, A. 'Choix des textes relatifs à la divination assyro-babylonienne', Paris, 1905/06, vols. i & ii.
(8) Breasted, H. 'Ancient Records of Egypt', Chicago, 3rd impression, 1927, iv, 376.
(9) Brugsch, H. 'Thesaurus', 1178–81, 11, 2–9; 1181–82, 11, 9–13.
(10) Brugsch, H. 'Zwei bilingue Papyri', vi, 4; v, 16; viii, 8; xi, 3.
(11) Brugsch, H. 'Hierogl. Dem. Wörterbuch', Leipzig, 1880–2, 506, 679.
(12) Brunnow, J. 'A Classified List of all Simple and Compound Ideograms', Leiden, 1889, nos. 11673, 11674.
(13) Burrows. 'Archaic Texts from Ur', London, 1937.
(14) Budge, E. A. Wallis. 'British Museum Guide to the Babylonian and Assyrian Antiquities', London, 1922.
(15) Chassinat, E. Le mot 'merhi' dans les textes médicinaux. *Recueil Champollion, Bibl. Ecole Hautes Études*, 1922, **234**, 447–67.
(16) Chiera, Edw. 'Selected Temple Accounts', Princeton, 1923, no. 11, col. iii, line 21.
(17) Claris, P. Analyse des résidus trouvés dans le grand sarcophage de Byblos. *Syria*, **4**, 1926, 79–80.
(18) Clay, J. 'Neo-Babylonian Letters from Erech', New Haven, 1919, nos. 98 & 161.
(19) Contenau, G. 'Contracts néo-babyloniens', Paris, 1924, no. 74.
(20) Contenau, G. 'Manuel de l'Archéologie Orientale', Paris, 1927, i.
(21) Cook, A. B., & Sheppard, C. Historical Records relating to Oil. *Journal Institution Petroleum Technologists*, 1927/28, 124–34.
(22) Coremans, P. *Chronique d'Egypte*, **24**, juillet 1937.
(23) Darmesteter, E. 'Études Iranniennes', i, 12–13.
(24) Deimel, A. 'Die Inschriften von Fara. Liste der archaischen Keilschriftzeichen', Leipzig, 1922, no. 768.
(25) Deimel, A. 'Sumerisches Lexikon', Rome, 1925 ff.
(26) Delaporte, L. 'La Mésopotamie', Paris, 1923.
(27) Delitzsch, F. 'Sumer. Glossar', Leipzig, 1914.
(28) Delitzsch, F. 'Assyrisches Handwörterbuch' Leipzig, 1896.
(29) Dussaud, R. Byblos et la mention des Giblites dans l'ancien Testament. *Syria*, 1926, **4**, 310.
(30) Driver-Miles. 'Assyrian Laws', p. 408, line 76, & note, p. 481.
(31) Ebbell, B. 'The Papyrus Ebers', Kopenhagen, 1937, 67.
(32) Ebeling, E. 'Keilschrifttexte aus Assur religiösen Inhalts.'
(33) Ebeling, Meissner, Weidner. 'Die Inschriften der altassyrischen Köninge', 74, 77.
(34) Ebeling, E. Liebeszauber im alten Orient. *Mitteilungen der Altorientalischen Gesellschaft*, **1**, 34.
(35) Epping-Strassmeier. *Zeitschrift für Assyriologie*, **6**, 242, Zeile 15.
(36) Falkenstein, A. 'Archaische Texte aus Uruk,' Leipzig, 1936.
(37) Fish, T. About Building in Ur III (Aspects of Sumerian Civilisation as evidenced on tablets in the John Rylands Library. *Bulletin John Rylands Library*, 1934, **18**, no. 1, 134–5.
(38) Fillion, H. Contribution à la chimie des charbons, pétroles, et asphaltes du Liban et de la Syrie. *Annales Faculté Française de Médicine de Beyrouth*, 1936, **1** & **2**.
(39) Forbes, R. J. Aus der ältesten Geschichte des Bitumens. *Bitumen*, 1934, Heft 1/3.

(40) Forbes, R. J. Untersuchungen betreffend die ältesten Anwendungen von Bitumen in Mesopotamien. *Bitumen*, 1935, Heft 1/3.
(41) Forbes, R. J. The Nomenclature of Bitumen, Petroleum, Tar and Allied Products in Antiquity. *Mnemosyne Bibl. Class. Bat.*, 3e Sér., **4**, 1936.
(42) Forbes, R. J. ' Bitumen and Petroleum in Antiquity ', Leyden, 1936.
(43) Forbes, R. J. Sketch of the History of the Petroleum Industry. *II Congrès Mondial du Pétrole*, Paris, 1937, R. 63, S. 5.
(44) Forrer, E. *Orientalische Literatur Zeitung*, 1937, **11**, 673–5.
(45) Fuÿe, Allotte de la. ' Documents présargoniques ', Paris, 1908–20, nos. 344–6.
(46) Genouillac, H. de. ' Inventaire des tablettes de Tello ', Paris, ii, 1910 ; v, 1921.
(47) Gruppe, O. Griechische Mythologie und Religionsgeschichte. *Handbuch der klassischen Altertums wissenschaft*, München, 1906, V. ii, 889, Anm. 4.
(48) Gsell, K. ' Eisen, Bronze und Kupfer bei den alten Ægyptern ', Karlsruhe, 1910, 79.
(49) Hall & Woolley. ' Ur Excavations ', London, 1927, vol. I, A, 'Ubaid.
(50) Hall, H. R. H. *Journal of Egyptian Archæology*, 1922, **8**, 247.
(51) Handcock, S. P. ' Mesopotamian Archæology ', London, 1912.
(52) Herzfeld, E. Masjid-i-Suleiman. *Naft Magazine*, Nov. 1929, **5**, 5–9.
(53) Herzfeld, E. ' Archæological History of Iran ', London, 1936, 93.
(54) Herzfeld, E. Le Mythe Aryen du naphte. *II Congrès Mondial du Pétrole*, Paris, 1937, S. 5.
(55) Heuzey, L. ' Nouvelles fouilles de Tello ', Paris, 1910–14.
(56) Hussey, Mary I. ' Sumerian Tablets in the Harvard Museum ', ii, 150.
(57) Jensen. ' Assyrisch-Babylonische Mythen und Epen ', Berlin, 1900, 236 ff.
(58) King, L. W. ' History of Sumer and Akkad ', London, 1916, 166.
(59) Köhler-Ungnad. ' Hammurabis Gesetz ', Berlin, 1904, iii, 128.
(60) Landsberger, B. *Zeitschrift für Assyriologie*, 1924, **35**, 233.
(61) Landsberger, B. *Zeitschrift für Assyriologie*, 1930, **35**, 226.
(62) Langdon, St. ' Excavations at Kish ', Paris, 1924, 4 vols.
(63) Langdon, St. Ausgrabungen in Mesopotamien seit 1918. *Der Alte Orient*, 1928, **26**, Heft 1.
(64) Langdon, St. ' Die neubabylonischen Königsinschriften.'
(65) Lippmann, E. O. von. Technologisches aus dem Sumerisch-Babylonischen Gilgamesch Epos, dem ältesten der Welt. *Archaion*, 1936, **18**, 305.
(66) Lockhart, L. Persian Petroleum in Ancient and Medieval Literature. *II Congrès Mondial du Pétrole*, Paris, 1937, R. 107. S, 5.
(67) Loret, V. L'asphalte ou Bitume de Judée. In *Études de Droguerie Egyptienne ; Recueil de Travaux édit. par Maspéro*, vol. xvi, 1894, 157–61.
(68) Lucas, A. *Journal Egyptian Archæology*, 1930, **16**, 46.
(69) Lucas, A. ' Ancient Egyptian Materials and Industries ', London, 2nd edit. 1934, 235–9.
(70) Lucas, A. ' Preservative Materials used by the Ancient Egyptians in Embalming ', Nat. Print. Dept., Cairo, 1911.
(71) Luckenbill, D. ' Annals of Sennacherib ', Chicago, 1924, 105, lines 88 ff.
(72) Maspéro, G. Le rituel de l'embaumement. In *Mémoires sur quelques Papyrus du Louvre*, Paris, 1875.
(73) Maspero, G. ' Guide du Musée de Caire ', Le Caire, 1908, 307.
(74) Mecquenem, R. de. Contribution à l'étude des outils en pierre trouvés dans les ruines de Suse. *Anthropologie*, 1923, **33**.
(75) Meier, Gerhard. Die Assyrische Beschwörungsserie Maqlû. *Archiv für Orientforschung*, Berlin, 1937, Beiheft 2.
(76) Meissner, B. Beiträge zum Assyrischen Wörterbuch. *Assyrian Studies*, no. 6, Chicago, 1932, 4–6.

(77) MEISSNER, B. ' Seltene Assyrische Ideogramme ', Leipzig, 1910.
(78) MEISSNER, B. Assyriologische Studien III, Lexicographisches XVIII, 12. *Mitteilungen Vorderasiatisch Ægyptische Gesellschaft*, 1905, **10**, 312.
(79) MEISSNER, B. ' Altbabylonisches Privatrecht ', no. 26, 116.
(80) MENGHIN, O. *Mitteilungen für ägyptische Altertumskunde Institut*, **3**, 151.
(81) MERCIER, MAURICE. Quelques points de l'histoire du pétrole. *Bulletin no.* 39 *de l'Association Française Techniciens du Pétrole*, 1937: *II Congrés Mondial du Pétrole*, S. 5.
(82) MESNIL DU BUISSON, F. DU. Les fouilles de Doura Europos et le naphte. *II Congrés Mondial du Pétrole*, Paris, 1937, S. 5.
(83) MUSS-ARNOLT. ' Assyrisch-Englisch-Deutsches Handwörterbuch ', Leipzig, 1905, 423.
(84) PERROT & CHIPIEZ. ' Chaldæa ', London, 1882, i, 383.
(85) POEBEL, A. *Zeitschrift für Assyriologie*, 1928, **39**, 145.
(86) RAWLINSON, G. ' The Five Great Monarchies of the Ancient Eastern World ', 3 vols, London, 1875.
(87) REISNER, G. 'Tempelurkunden aus Tello', 113, 121, line 12, and col. v, line 19, ff. 122.
(88) SARZEC, H. DE, et HEUZEY. ' Découvertes en Chaldée ', 2 vols., Paris, 1884–1912.
(89) SCHAEFER, H. ' Ægyptische Inschriften aus dem Kgl. Museum in Berlin ', vol. i, 22.
(90) SCHEIL, V., et GAUTHIER. Annales de Tukulti Ninip II. *Bibliothèque des Hautes Études*, no. 178, Paris, 1909.
(91) SCHOO, J. Romeinsche aardoliewinning aan de golf van Suez. *Tijdschrift Nederlandsch Aardrÿkskundig Genootschap*, **51**, 1934, 883–8.
(92) SCHRÖDER, O. ' Keilschrifttexte aus Assur verschiedenen Inhalts ', xiv, Leipzig, 1920.
(93) SÉGUIN, A. Recherches sur le pétrole dans l'antiquité. *Revue des Questions Historiques*, Janv. 1936, 3.
(94) SÉGUIN, A. Étude sur le pétrole dans l'antiquité égyptienne. *II Congrés Mondial du Pétrole*, Paris, 1937, R. 43, S. 5.
(95) SÉGUIN, A. Étude sur le pétrole dans quelques pays de l'Orient ancien.—I. Canaan et la Phénicie. *II Congrès Mondial du Pétrole*, Paris, 1937, R. 45, S. 5.
(96) SÉGUIN, A. Étude sur le pétrole dans l'Asie Occidentale Ancienne. L'Elam et la Mésopotamie. *II Congrès Mondial du Pétrole*, Paris, 1937, R. 44, S. 5.
(97) SETHE, K. ' Urkunden ', Leipzig, 1924, vol. i, 145–7.
(98) SETHE, K. Zur Geschichte der Einbalsamierung bei den Ægyptern. *Sitzungsberichte Preussische Akademie Wissenschaften*, 1934.
(99) SMITH, W. ' Concise Dictionary of the Bible.'
(100) SPIEGELBERG, W. Ein Bruchstück des Bestattungsrituals der Apisstiere. *Zeitschrift für ägyptische Sprache*, 1920, **56**, 1–33.
(101) SPIELMANN, PERCY E. To what extent did the Ancient Egyptians use Bitumen for Embalming. *Journal Egyptian Archæology*, 1928, **18**, 177–80.
(102) STRASSMAIER, J. N. ' Die Inschriften des Nabuchodonosor ', Leipzig, 1887.
(103) STRASSMAIER, J. N. ' Die Inschriften des Nabonidos ', Leipzig, 1887.
(104) STRASSMAIER, J. N. ' Die Inschriften des Cambyses ', Leipzig, 1887.
(105) THOMPSON, R. CAMPBELL. ' Assyrian Medical Texts ', Oxford, 1923.
(106) THOMPSON, R. CAMPBELL. ' Cuneiform Texts ', British Museum, London, xxii, no. 84.
(107) THOMPSON, GRIFFITH. ' The Two Demotic Magical Papyrus of London and Leiden,' xiv, 23.
(108) THUREAU, DANGIN F. ' Textes mathématiques babyloniens ', *Revue d'Assyriologie*, **33**, 1936, no. 2, p. 79.
(109) THUREAU, DANGIN F. ' Inscriptions de Sumer et d'Akkad ', Paris, 1905, p. 157.

(110) THUREAU, DANGIN F. *Revue de Assyriologie*, **33**, 1926, 65.
(111) THUREAU, DANGIN F. ' Lettres et Contracts ', Paris, 1927, nos. 237 & 238.
(112) TOUTAIN, J. Sur l'ancienneté des gisements de pétrole de la région de Mossoul. *Bulletin Société Sciences historiques et naturelles Semuren-Aussois*, 1926, no. 4, 3–4.
(113) UGNAD, A. ' Das Gilgamesch Epos ', Göttingen, 1911, 31, 49, 51, 54, 194, 215.
(114) WATELIN, A. Rapport des fouilles de Kish. *Journal Asiatique*, 1929, 107–18.
(115) WILKINSON, J. G. ' Manners and Customs of the Ancient Egyptians ', London, 1878, 3 vols.
(116) WOOLLEY, C. L. Excavations at Ur. *Antiquaries Journal*, **8**, 1928, 1.
(117) WOOLLEY, C. L. ' Ur Excavations ', London, 1934, ii, 145.
(118) WOOLLEY, C. L. ' Digging up the Past ', London, 1930.
(119) ZIMMERN, H. ' Beiträge zur Kenntnis der Babylonischen Religion ', Leipzig, 1896–1900.

CHEMISTRY AND ALCHEMY IN THE NATURAL PHILOSOPHY OF SIR FRANCIS BACON, 1561–1626.

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For history Sir Francis Bacon is the Lord Chancellor who intrigued for the seals, took bribes and betrayed Essex; for literature he is the author of the *Essays* and a great writer; for philosophy he is the author of the *Novum Organum* and a renovator of knowledge. For the chemist, as such, he is, perhaps, a less figure, but chemical and alchemical items are scattered through his writings, and these are often significant of his thought.

If *all* bodies have 'perception', even when they have no 'sense', and these perceptions are often 'subtile', inanimate things are not conceived wholly mechanically. Physical bodies are not conceived wholly mechanically if, as Bacon insists, the perceptions that pervade nature precede operations. In the Baconian physics air or a trembling candle has a 'subtile perception' of a wind that men do not feel, water perceives the passages as it enters a sponge, and a body perceives the force of another body to which it yields or the removal of another body from itself. Physics has not been wholly mechanised when reciprocal perception precedes operation. Bacon warns men to heed the important distinction between 'simple perception' and 'sense': Whitehead notes his careful discrimination of *perception*, which *takes account of*, from *sense*, which is cognitive experience [1].

Appetites and passions accompany the perceptions in matter, for all things prefer the congenial and shun the unwelcome. 'Sympathies' and 'antipathies' seem to the mechanically minded modern to be metaphorically applied to physical things: strife and friendship seem to be 'spurs of motions' in the inanimate world only figuratively. Bacon, however, insists on the correspondence between the passions of bodies with and without sense. When the future inertia appears as abhorrence of motion it appears as an inanimate analogue of conscious or sensitive dislike. When gold greedily drinks in quicksilver its appetite is a 'kind of thirst' that is not conscious. Sympathetic approaches to assemblages of kindred substances are inanimate analogues of social responsiveness—long after Plato like substances were constantly presumed to gather in groups, just as birds of a feather flock together [2].

[1] *Natural History*, Century ix, Section 800; *The Advancement of Learning*, Book iv, Chapter 3; Whitehead, A. N., *Science and the Modern World*, Cambridge, 1926, 59.

[2] *Adv. L.*, iii, 4; *Nat. Hist.*, viii, 800; *Novum Organum*, Book ii, *Aphorisms*, 36, 48; Spedding, J., Ellis, R. L., and Heath, D. D., *The Works of Francis Bacon*, New Edition, London, 1868–92, *The History of the Sympathy and Antipathy of Things*, v, 203; *Thoughts on the Nature of Things*, v, 432.

Bacon seems to have been as liable to hylozoistic misunderstandings of mechanical conceptions as we are to mechanical misinterpretations of his reduced hylozoism or animism. When he surveyed ancient myths he identified the elder Cupid with the atom. The little boy-god represented the original sentiency of matter, and he was blind because that sentiency had little foresight. He was a boy because the atoms were the perpetual infants of the world; he was naked because in the atoms alone was matter truly stripped; he was an archer because the atoms attracted one another from a distance. The nakedness and perpetual infancy were true of ancient atomism; neither the archery nor the sentiency were. Bacon, though he speaks of the 'natural motion' of the atom, associates 'simple desire' and 'primary motion'. He qualified the mechanical atom by a more animistically conceived sentiency [3], and the tradition that blinded him to the mechanical rigour of Democritean Atomism preserved an animistic remnant in his physics. Bacon is transitional between a hylozoistically or animistically tinged version of inanimate nature and the Cartesian mechanical version.

Schopenhauer, in a note added to his *The World as Will and Desire*, associates Bacon's notion of physical movement preceded by perception with Kepler's notion that the planets know how to regulate their paths. Bacon, however, dissociates the perceptions of physical things too insistently from 'sense' for inanimate perception, passion and appetite to be more than inanimate analogues of sensitive or conscious behaviour.

The modern chemist might puzzle over the production of heat during the slaking of quicklime by the exasperation of the fiery spirit within. The struggle between the irritated spirit and the water is intelligible, though not acceptable, from Bacon's remarks on *antiperistasis*. Through antiperistasis, he remarks, opposition augments every passion, and the rise of a civil faction incenses its rival. According to this social analogy the spirit in the lime is provoked to violence by the cold water, just as when A hits B, the angered B hits fiercely back at A [4].

Boyle was familiar with the notion that a 'besieged quality' multiplies its power against a menace. Eusebius thought that the menacing cold of the water angered the internal heat of the lime, and stirred it to calorific fervour [5]. Thus the lime-and-water antiperistasis was an old tradition. Boyle warred against the inanimate analogues of animate behaviour, and they perished in the mechanical versions that prevailed after Descartes. Those in antiperistasis, in particular, partly perished in the Newtonian action and reaction, which was physically conceived.

In the Baconian physics 'spirits' urge much of the dynamism on nature.

[3] *De Sapientia Veterum*, Spedding, &c., vi, 654.

[4] *Adv. L.*, ii, 13; iii, 1; *Nov. Org.*, ii, 12.

[5] Birch, T., *The Works of the Honourable Robert Boyle*, 1772, ii, 423, 659 f; iii, 479; iv, 60, 246.

Bacon derived these ' spirits or pneumaticals ', the rulers of nature, from tradition, though he interpreted them by observation, experiment and his own appeal to Minerva, as he called the final recourse to ' reasoning and true induction '. The traditional animal spirits still raced through conduit nerves, to serve sensation or excite motion, till Gall, 1758–1828, dismissed them. Bacon drew on the tradition when he compounded them of flame and air. He drew again on tradition for their chief location in the brain, their run through nerves, and their nourishment by the spirituous blood of the arteries. He suspected birds of longevity because their heads are small, and men with very big heads of being shorter lived because they have too much ' spirit '. He argued from the living to the inanimate by distinguishing the ' vital spirit ' of the former from the ' native ' or ' lifeless spirit ' of the latter [6].

In the Baconian System the vital spirit in a living thing is continuous and branched—either in minute canals, as in some animals and in plants, or in both channels and cells, as in ' the nobler animals '. In an inanimate thing the spirit is distributed in separate portions, like air in snow. Also the spirits of inanimate things are not ' flamy ', and they cannot be recruited from blood. ' The pneumatical part which is in all tangible bodies ' differs as much from air as wine from water, though it is akin to air, and the ' lifeless spirits ' are once said to be ' nearly of the same substance as air '. These governing agents of the physical world are highly rarefied natural bodies, and all tangible bodies contain these invisible, intangible and weightless spirits. All living things contain them in addition to their own peculiar vital spirits, which are also invisible, intangible and weightless. Differing bodies have differing spirits, and each enclosed pneumatical may feed on the tangible parts by rarefying them, and so increase itself [7].

Metals, according to Bacon, can be melted because detained spirits play within them : this illustrates the restlessness of the spirits and their active rôle in natural processes. Quicksilver, apparently, has more spirit than any other metal because it is always liquid ; it is also said to be the coldest metal because it is so rich in spirit [8].

Bacon's ' pneumatic bodies ' are the vapours and gases of science, though it is, perhaps, well to think in his terminology to avoid possible intrusions of modern ideas. The fumes of metals and various other substances are volatile rather than pneumatic, since they ' are very easily coagulated ', or condensed. Thus the pneumatic bodies proper are permanently, or relatively permanently, rarefied matter. They include, as members of a very varied miscellany, various ' fumes ', ' vaporous fumes ' from watery bodies,

[6] *Nov. Org.*, ii, 7 ; *Nat. Hist.*, iv, 354 ; ix, 842 ; *Adv. L.*, iv, 3 ; *Historia Vitæ et Mortis.*, Spedding &c., v, 240, 322.

[7] *Hist. Vit. Mort.*, Spedding &c., v, 324 ; *Nov. Org.*, ii, 7, 40, 42 ; *Nat. Hist.*, vii, 601.

[8] *Nov. Org.*, ii, 24 ; *Nat. Hist.*, i, 73, 98 ; ix, 840.

'breaths' from fermented liquors and 'exhalations' from 'oily bodies'. All these pneumatic bodies are *imperfect.*

Air and flame are the only two 'pure' pneumatic bodies, though even they can vary greatly, and may have 'unequal degrees of bulk'. Air is rarefied water. Flame has an oily nature: it is rarefied oil or combustible matter.

The pure air and flame, like the imperfect pneumatic bodies, are found free. The 'spirits' are 'attached' pneumatic bodies—enclosed in tangible things [9]. Oil and water are successfully 'mixed' in herbs, blood and animal parts; this mixture, when rarefied into vital spirit, confers great powers upon the characteristic spirits of living things, for this incorporation of air and flame, flowing urgently 'in the cells of the brain and canals of the sinews', can hurl the wrestler's great body forcibly or move the flute-player's fingers swiftly. These vital spirits abound in the ventricles of the brain, but they are absent from inanimate things. The 'lifeless spirits', 'attached' both to inanimate and animate bodies, are various rarefied matters, but they do not contain flame. They are the characteristic spirits of inanimate nature, as the vital spirits are characteristic of the living [10].

Bacon also distinguishes a superior order of 'pneumaticals' from the inferior order that contains air and flame. The members of this superior order contain 'the body of the star and the pure sky' [11].

The spirits can be emitted, though they are characteristically enclosed, or attached, and not free. Such intangible emissions may retain gross tangible parts. The odours of various exhalations, which often adhere to hard bodies, as perfume to gloves, disclose such retentions. We distinguish gases or vapours from clouds or fogs or smokes in volatilised products; Bacon similarly recognises rarefied intangible pneumatic bodies, or spirits, from grosser tangible emissions [12].

Bottled beer spirts when the stopple is removed because it is 'full of spirit'. Air and flame are similar to these 'subtile or windy spirits', or 'breaths', from bodies, such as fermented liquors, that have inflammable spirit and watery substance. Since enclosed spirits are eager to join the air and enjoy the sunbeams, the windy spirit of unstoppered beer may froth out to reach the air and sunlight. An invitation from the ambient air is one cause of the emission of spirits. They may also exhale simply because they are restless or they may be irritated into issue by heat or fire. If the windy spirit does accept a welcome invitation from the air when it foams out of the bottle, Bacon's distinction between 'perception' and 'sense' reduces its *appetite* to an inanimate analogue of human liking for the air and light [13].

[9] *Historia Densi et Rari*, Spedding &c., v, 349 ff.; *Hist. Vit. Mort.*, Spedding &c., v, 224, 268 ff., 321 ff.

[10] *Nov. Org.*, ii, 42; *Nat. Hist.*, i, 30; iv, 400; vii, 601.

[11] *Nat. Hist.*, iv, 354.

[12] *Hist. D. R.*, Spedding &c., v, 351; *Nat. Hist.*, ix, 834.

[13] *Hist. D. R.*, Spedding &c., v, 349; *Nat. Hist.*, i, 23; iv, 314, 328.

The Baconian ' spirits ' can be conveniently regarded as restless airs or gases, though we must think like Bacon to understand him, and not like a modern physicist. Bacon carefully distinguishes the ' native spirit ', that is distributed piece-meal in containing cavities through an inanimate thing, from ' plain air that is gotten in '. Since unconfined spirits disperse like unenclosed gases, Bacon compares the tangible parts of the confining bodies to integuments. The spirits, like all pneumatic bodies, are *weightless*: ponderable tangible parts are rarefied into imponderable intangible spirits [14].

Though Bacon fits data and deductions effectively into a system, his expositions might have been embarrassed if he had known that rusts are heavier than the original metals. He includes under ' rusts ' such substances as ' verdigrease ' and the products obtained by subjecting metals to ' simple fire ' or the action of ' any salt, sour, or acid water '. Spirits, hankering after air and light in their own inanimate way, escape from the substances. They dilate to escape, press on the grosser parts of the body, and the rust is the visible trail of their flight. Mercury can be rusted by calcination : Bacon calls the red product ' vermillion ', and observes that it can be obtained also by solution. Gold does not lack spirit, for it can be melted, but the tangible parts of the metal are spread too uniformly and too closely for the spirit to escape. This compactness of gold both shuts the spirit in and diminishes its appetite to escape. The imperfect metals are subject to rust. Though gold holds its spirit too securely to be rusted and mercury requires solution or calcination to become ' vermillion ', moisture usually hastens rusting. The moisture softens the confining crust and eases the escape of the spirits. The ' crust ' is, apparently, simply the outer portion of the ' integument ' constituted by the whole body : neither spirit nor air is readily rarefied enough to pass through the pores of most solids, as water does not escape through small chinks [15].

The rusts are often coloured because their parts are appropriately disposed and coarse enough. Enough quick spirit also remains in the rust to help the colouring effect of the disposed parts : ' equal posture and quick spirits are required chiefly to make colours lightsome ' [16].

Bacon includes the rusts among the putrefactions. Desiccated substances have lost much spirit. When heated bodies retain their spirit they soften, like hot iron, or melt, like many metals. Metals rust or flesh putrefies when the spirits are partly emitted and partly retained. The rusts are not rudiments of life, but in a sufficiently pliant substance, which does not lose its spirit too

[14] *Hist. D. R.*, Spedding &c., v, 349 ff. ; *Nov. Org.*, ii, 40,48 ; *Nat. Hist.*, i, 98 ; viii, 774 ; ix, 842.

[15] *Nat. Hist.*, iii, 291 ; iv, 328, 336 ; viii, 799 ; *Nov. Org.*, ii, 50 ; *Physiological Remains, The Works of Sir Francis Bacon*, London, 1824, ii, 204 ; *Hist. Vit. Mort.*, Spedding &c., v, 222, 224, 232 f.

[16] *Nov. Org.*, ii, 22 ; *Nat. Hist.*, iii, 291.

quickly or restrain the detained spirit too obstinately, the striving spirit fashions the tangible parts into an organic body. Thus putrefaction converts flesh or cheese into animalculæ, or eggs into ants. Frogs also appear after rain. Bacon regards the fœtus in the womb as a putrefactive product. Thus putrefaction may prepare for a new generation, though rusting does not [17].

Spirit is the great putrifier, and moisture is its assistant. Warmth may also promote putrefaction, in which there is always some degree of heat. Wine becomes vinegar by a kind of putrefaction that is checked by excluding the air. The air invites the spirits, and the spirits respond if they can. If they cannot respond, putrefaction cannot occur. Two great depredators produce waste—internal spirit and the external air. In putrefaction the air, according to Bacon's expositions, is the accomplice, for it solicits the spirits and receives them [18].

Cloth sucks up water in an amusingly quasi-animistic way : the cloth does not like the air in its pores, so it imbibes water, if it can, to expel the unwelcome pneumatical. Gold, or any metal in leaf, dislikes the air as a neighbour. The antipathies of tangible bodies would seem to confine the air largely to a receptacular rôle, though water is its natural prey, since it is itself highly rarefied water. Tangible bodies, however, because they dislike the air, try to convert it into a dense body. If stumps of trees sprout, as they lie forlorn on the ground, because they condense air into a dense substance, then air can nourish. Bacon suggests that the condensed air may also increase the weight, and suggests, further, that the stumps be weighed before and after sprouting. If the sprouted stumps do gather weight, Bacon adds, it shows that air can be condensed and nourish : it is also *magnale naturæ*. It seems to be if the stumps gather weight by condensing *weightless* air. This is no contradiction in the Baconian physics, for the system is adapted to remove the apparent anomaly [19].

Bacon constantly repeats that the sum total of matter is constant, and constantly insists that natural body is neither created out of nothing nor reduced to it. This is axiomatic in physics and true in Natural Theology, though Providence can do what nature cannot. Because inflation does not alter the weight of a deflated bladder Bacon deduces that air cannot diminish or increase weight. All the pneumatic bodies, including air, are *weightless*. Weighty water is converted into weightless air, and ponderable tangible matter is converted into imponderable spirit. The redistributions of a constant sum of matter do not involve a constancy of weight. Rarefaction does not merely thin out weight—it diminishes it ; condensation does not merely pack weight in—it increases it [20].

[17] *Nov. Org.*, ii, 13, 40, 41, 48.
[18] *Nat. Hist.*, iv, 343, 350 ; ix, 836, 858, 898 ; *Adv. L.*, iv, 2.
[19] *Nov. Org.*, ii, 48 ; *Nat. Hist.*, i, 27, 29, 80.
[20] *Nov. Org.*, ii, 40 ; *Adv. L.*, iii, 1 ; *Hist. D. R.*, Spedding &c., v, 339 ff.

According to some casual remarks by Bacon, a body may be too small to have weight, and the dust on the balance ' appeareth, but weigheth not '. This might imply that *weightlessness* simply means imperceptible heaviness, not complete imponderability. The pneumaticals, however, are repeatedly called weightless—without any qualification. In any event rarefaction diminishes weight, and bodies lose weight when their parts are rarefied into weightless spirit. They lose weight even if the spirit remains in them, for the detained spirit, being weightless, cannot make them heavier. The body may even be lighter than it would be if the spirit were not present in it. The contrast between the dead weight of the corpse and the pliancy of the living body probably suggested that when the enlivening animal spirits departed at death they left the mass that they had enlivened heavier. Bacon thinks that living spirit does diminish the weight of the animated body, though not so much as is commonly thought. Native spirits, therefore, *may* analogously make inanimate bodies lighter. Contained or entangled *air* does not make bodies lighter, for a sponge or fleece filled with air is no lighter than when the air is excluded. A fleece does become heavier by lying long on the ground because something pneumatic is condensed into something ponderable. So the sprouting stumps *may* become heavier by condensing weightless air into ponderable water [21].

Air is an active depredator as well as a receptacular assistant of depredation. It preys upon terrestrial matter to increase itself—winds occur in the lower atmosphere when water is converted into a surplus of air. Rain is a constant reminder that a conversion of the upper air into water maintains the conservation of things. In desiccation the air also multiplies itself by attacking the innate spirits and juices (possibly by transforming their watery parts). Air condenses into water, and water freezes into ice, but, according to Bacon, air cannot become solid. In discussing the freezing of water he refers to its ' spirit ' and ' pneumatic part '. Water is also called one of the simplest of bodies. Bacon's allusion to ' fore-fumes ' in the *Historia Densi et Rari* may relieve, if not banish, the apparent anomaly of a non-solidifiable air becoming ice after becoming water. Bacon accommodates one difficulty by interposing ' after-fumes '—the air will not receive the tapering flame, but it does receive the after-fumes into which the flame transforms. Smoke and its final coagulum, soot, in accordance with Bacon's remarks about ' volatile fumes ', suggest the special ' after-fumes ' assigned as the successors of flames. ' Fore-fumes ' between water and air do not avoid a difficulty so neatly as the ' after-fumes ' of flames, and they may not smooth out the apparent anomaly at all. Vaporous fumes are said to exhale from water and watery bodies, but such ' moist vapours ' seem to be simply vaporized moisture : water can moisten air and air can be watery. The ' version ' of air into water, though always *magnale naturæ*, and the reverse process seem to be direct transformations,

[21] *Hist. D. R.*, Spedding &c., v, 387.

though spirit or moisture is said to evaporate into ' spirit '. Bacon realised that the version of actual air into water is difficult—this is evident both in his description of it as *magnale naturæ* and in his suggestions for effecting it [22].

This short hunt through Bacon's ideas is more likely to be useful in disclosing his notions than in fitting into his system so great an error as the presumed conversion of air into water. Both air and water are suspected of putrefying and so causing diseases [23]. If the sprouting stumps do convert air into a dense body, this body *may* not be water.

Bacon repudiates the ' vulgar opinion ' that flame is ' air incensed ', or the ' vain conceit ' that it is ' lighted air '. He is aloof, also, from the notion of air as a nourisher or the aliment of fire. The great source and aliment of flame is oil, and these two have the same nature. Inflammable substances have oily characters : spirits of wine, for instance, has both an oily and a watery nature. Flame is rarefied oil, or inflammable matter, as air is rarefied water [24].

The qualified hostility between oil and water appears in the relation of flame to air. The manifest reluctance of oil and water to mix is overcome in the assimilation of nourishment by plants and animals, in the beginnings of putrefaction, and in other processes. Though ' oil is almost nothing else but water digested ', this conversion is one of the greatest *magnalia naturæ*, for the two have little affinity. Though oil and water, or flame and air, are potently mingled in vital spirits, the ambient air and the mounting flame refuse to mix : a froth can be compounded of air and liquor, and a fiery froth of air and flame issues from exploding gunpowder, but the flame of a candle and the surrounding air remain inimical [25].

Heat dilates oil and oily inflammable bodies suddenly, and with great expansion, into flame. This highly rarefied and mounting oil would be globular, like the true celestial fires, but the air, refusing to receive it more than momentarily, quenches its sides, presses on it and crushes the flame into a pyramid. The flame, hindered and extinguished by the air, becomes a pneumatic after-fume which the air receives. As the flame constantly passes into after-fume, the oily aliment, or fuel, constantly passes into flame. The apparently steady flame is a series of perishing flames—it is perpetually generated and extinguished because it lives among hostile things. An arrow held across the flame of a candle for ' ten pulses ' is blackened where it cuts the sides of the flame, and little affected between the two scorchings. Thus the flame is violent where the air checks it and compels it to change into smoke. The inner flame is ' fixed ', or relatively permanent, but the outer mantle is constantly destroyed

[22] *Hist. D. R.*, Spedding &c., v, 351, *Hist. Vent.*, Spedding &c., v, 162 ff. ; *Hist. Vit. Mort.*, Spedding &c., v, 335 ; *Nov. Org.*, ii, 33, 48, 49 ; *Nat. Hist.*, i, 99 ; ix, 865.

[23] *Nat. Hist.*, ix, 800.

[24] *Hist. D. R.*, Spedding &c., v, 352, 354, 377 ; *Hist. Vit. Mort.*, Spedding &c., v, 335 ; *Nov. Org.*, ii, 42 ; *Nat. Hist.*, iv, 354.

[25] *Hist. D. R.*, Spedding &c., v, 356 ; *Nat. Hist.*, iv, 354–9.

and replenished. The after-fume becomes the carcass of the flame in soot. This suggests an enquiry into spirits of wine, for this has not a fuliginous flame [26].

The familiar experiment of enclosed combustion may have been modelled on the cupping-glass : Bacon usually mentions the two together. He describes the heating of the glass to expand the air within it, its application to the skin, the cooling of the air, and the attraction of the flesh by the ' motion of connection '. The flesh moves up to avoid a vacuum as the cooling air retracts. This motion of connection to clear away vacua, or prevent them, results from intercourse between the parts of the universe, and is stronger than the gravity, which is concerned only with the intercourse of dense bodies. In nature, Bacon adds, the public good usually prevails over private benefit, though not, unfortunately, in civil life. If the cupping-glass is placed over a burning candle and with its mouth in water instead of on flesh, the step has been taken to the experiment of enclosed combustion. As Bacon describes it, a lighted candle is placed in the bottom of a basin of water, and the mouth of a pot is turned over the candle. The motion of the rising water is seen better if a glass is used instead of a pot. Since Bacon calls the experiment ' common ', this familiar and important experiment was well known in the earlier seventeenth century.

As the candle goes out the water rises in the pot, as flesh rises in the cupping-glass. Flour or sand in the ' bason ' behaves like the water. In one experiment with oil instead of water the glass, when raised by the hand, lifted the basin with it. The water does not rise fully until the candle is extinguished, though it rises slightly as the flame diminishes, because the air and the water move to fill the now vacant place of the flame. This also is a ' motion of nexe ', a motion of connection to avoid a vacuum [27].

The flame is not simply a conjunction of heat and light, though it is obviously hot and shining. Bacon complains that the ' form of light ', scripturally the ' first created form ', has been neglected for the study of its radiation : the pains spent over perspective have left few for the origin of light. He suspects that light takes time to travel, and in his *Topica Inquisitionis de Luce et Lumine* he sketches a preliminary assembling of the data relevant to its ' form '. He drops the suspicion, and he deduces only that light has principal affinities with heat, tenuity and motion. He watches prisms and crystalline gems spread light into colours on the wall, deduces that bodies depend for their colours upon the placing of their coarser parts, and infers that colour is the broken or modified image of light, but the form of light is left indeterminate [28].

[26] *Nov. Org.*, ii, 36 ; *Nat. Hist.*, i, 30–2 ; *Hist. D. R.*, Spedding &c., v, 351 ; *Thoughts on the Nature of Things*, Spedding &c., v, 435 ff.

[27] *Thoughts on the Nature of Things*, Spedding &c., v, 428 f. ; *Hist. D. R.*, Spedding &c., v, 361 ; *Nov. Org.*, ii, 48, 50 ; *Nat. Hist.*, ix, 889.

[28] *Adv. L.*, i ; iv, 3 ; *Nov. Org.*, ii, 20, 22, 46, 49.

Bacon is more persevering and more successful with the ' form ' of heat. When a modern newspaper mentions the ' form of Aristotle ', it means a race-horse. Bacon is respectful to the Greek Aristotle as a great philosopher with insight. He also accuses Aristotle of dragging experiment captive, and rudely identifies the Aristotelian physics with mere logical terms. This disparagement of Aristotle involves no break with ' forms ', for Bacon still thinks largely in terms of these traditional concepts. His choice of heat, in the *Novum Organum*, to illustrate his renovating method is fortunate for the study of his physics. His final conclusion, or provisional hypothesis, is also significant : it marks the transition from interpretation by forms to exposition by particles, and a second transition from quasi-animism to purely mechanical notions. His analysis of heat also, in the *Novum Organum*, is probably our clearest indication of what Bacon meant by a ' form '.

' Sensible heat ', the sensation of warmth, is the effect on animal spirit of the ' substantial self ' of heat in the hot body. It is relative to the senses, for lukewarm water is hot to a cold hand and cold to a hot one. Heat itself is the simple ' form ' in bodies themselves. It is in those bodies, just as are the simple forms of density, rarity, gravity, levity and cold. It reveals itself to man by producing a sensation of warmth in his vital spirit. Bacon says that old nasturtium and various aromatic substances have heat because they warm the tongue and may almost burn it. Non-sensible heat can also manifest itself by its effects on natural bodies. Bacon cites the inside of an egg thrown into spirits of wine, which is poached and whitened as it would be if it were heated. Bodies which are not warm to the hand may also have heat potentially or preparatively : naphtha is predisposed to flame, and the imparted heat latent in cold lime is excited by sprinkling it with water [29].

Sensation prompts us to regard heat and cold as two separate things. The sensations of coldness and warmth *are* two different things, even if cold and heat are physically different degrees of temperature. Bacon, therefore, is not surprised to discover that Telesius regards cold as an active rival of heat and not merely its privation. Bacon himself hovers several times over the notion that cold is a comparative heat, but he does not elucidate the ' form ' of cold as he elucidates the form of heat, and the two apparent contraries remain separate and opposed. They are separate enough to provoke one another by antiperistasis when cold contracts itself in the middle air to resist the rays of the sun, or fires burn more fiercely in a sharp frost because the cold exasperates the heat [30].

Since flames and rubbed bodies are hot, they seem to contain the form of heat. Other instances are collected with them without making any premature decisions. Bacon's inclusion of the hardening of egg white by spirits of wine

[29] *Adv. L.*, iii, 4 ; *Nov. Org.*, ii, 11–13, 20 ; *Hist. D. R.*, Spedding &c., v, 384.

[30] *On Principles and Origins, &c.*, Spedding &c., v, 490 ; *Hist. D. R.*, Spedding &c., v, 392 ; *Nov. Org.*, ii, 13.

and of aromatic bodies that burn the tongue does not lead him astray. This collection of apparently obvious instances in the first table is the first step [31].

Light or flame are probably excluded from the form of heat because the moon's rays are not warm, *ignis fatuus* has little heat and rotten wood shines without warmth. Though spirits of wine and oil of vitriol have the effects of heat, these and other liquids are not naturally warm. This illustrates, without completely describing, Bacon's second step of collecting instances in which the form of heat might be expected but may not be present [32].

The third table of the third step collects instances in which there are comparative degrees of heat. Sprinkled water, for example, makes cold lime hot. Flames vary in strength from the gentle fire exhaling out of spirits of wine to the fiery heat of burning naphtha. Bacon's collection significantly includes the increase of heat by *motion* in the bellows and blow-pipe. Defective knowledge inevitably includes the doubtful with the authentic, but induction can now review the instances in the three tables to discover how far a certain nature and heat are present or absent or variable together. In discovering the form of heat, or law of simple action that constitutes its simple nature, legitimate induction first *excludes* those natures that are not present when heat is present, absent when heat is absent and that do not vary with the variations of heat [33].

Flame or light, for example, is not the form of heat, for boiling water or heated air do not shine. To avoid confusions from mechanical tabulations and cancellings the mind must seek interpretively for the 'affirmative'—the nature that is the law or form of heat. This 'first vintage', as Bacon calls the first interpretative effort, corresponds to the modern provisional hypothesis. If it does prove to be false, truth still emerges more readily from error than from confusion. Conspicuous instances, in which the form is highly evident, point to *motion*. Destruction by fire, or great changes wrought by strong heat, suggest violent motions in the internal parts of bodies. Such motion tends upwards—this is conspicuous in distillations *per decensum*. It is expansive, for bodies dilate under heat; it is not expansive motion of the whole, for air expands at times when no warming up is manifest [34].

In the expansive motion of heat the smaller particles throw themselves against restraint. Under this opposition the motion is repulsed and reflected into an alternating struggling tumult. The smaller particles that compose the calorific confusion are not the most minute: time seems to reduce more finely than fire, yet without perceptible heat, because the motion is slow and the very minute particles are, in this case, attacked.

[31] *Nov. Org.*, ii, 11.
[32] *Nov. Org.*, ii, 12.
[33] *Nov. Org.*, ii, 13–17.
[34] *Nov. Org.*, ii, 18–20.

According to this first vintage, or provisional hypothesis, heat is a restrained expansive motion that strives in the smaller particles. The expansion tends upwards, and the effort is not sluggish but violent. This is the form, or essence, lodged in natural bodies, of the sensible or operative heat that is manifest to human senses. Knowledge of the form shows how to superinduce the corresponding nature upon matter ; to produce heat, therefore, excite expansion in a natural body and repress it so that it can only proceed unequally [35]. This happens, as Bacon's discussions show, on the partitioning mantle where the flame and air adjoin.

The internal tumult of heat is not conceived wholly mechanically, for the irritation of the moving particles by repercussion and thwarted movements is the source of violence in heat and flame. This is antiperistasis in the heart of mechanical movements—antiperistasis in which opposition or resistance excites a responding vigour. This violence, this fury roused through opposition, rages in the hot mantle of the candle-flame where the mounting fire expands against the resisting air. Cold in the air, by a second antiperistasis, irritates flames into burning more fiercely. Bacon's quasi-animism allows more analogy than modern physics would permit between this partitioning mantle and the frontier that divides two hostile tribes. In their own inanimate way the thwarted particles are like men angered by opposition [36].

This first vintage has been gathered from the three tables of the first review ; other aids to understanding can further help inquiry along [37].

Later on in the century Boyle described the ' Forme ' of a natural body as the stamp of its matter—the dispositions and movements of its constituent particles with their resulting qualities. Bacon's ' form ' of heat, an internal tumult of smaller particles, is a precursor of this description. Later on in the century, also, Boyle attacked the introduction of morals and politics into corporeal natures that acted only under mechanical laws. Bacon's antiperistasis still retains the animistic remnant and his physics the quasi-animism that displeased Boyle when he condemned hostilities between alkalies and acids, friendship within the tribe and duels between physical things [38].

Bacon's notions of flame are significant of his thought. The mounting expanding oil embodies the natural tendency of bodies to become more pneumatical and rarefied. This rarefaction that is so characteristic of natural processes has to conform to the continuity that excludes vacua. This conformity is secured through a folding of matter by which, within certain limits, matter wraps and unwraps itself in space [39].

[35] *Nov. Org.*, ii, 20.

[36] *Nov. Org.*, ii, 20 ; *Nat. Hist.*, iv, 375.

[37] *Nov. Org.*, ii, 21–52.

[38] Boyle, *The Origine of Formes and Qualities*, ed. 2, 1667, 101 ; Birch, T., *The Works of the Honourable Robert Boyle*, 1772, iv, 289–91.

[39] *Nov. Org.*, ii, 48 ; *Nat. Hist.*, i, 29.

A's animal spirits, warmed by wine, urge his arm violently, and his clenched fist hits B's eye. B's spirits move ' to succour ' his damaged part, drawing humours with them, and swell the bruise. If this is parody it still expresses the interconnected rôles of heat, spirit and motion in Bacon's Natural Philosophy. A cold compress on B's swollen eye adds a fourth important natural agent to the list.

Bacon speaks of ' motions ' as ' active powers ' ; he says of nature that heat and cold are her two hands, that heat is her chief power, and that she owes most of her effects, such as maturation, to the movements of spirits. Experience deduces the invisible motions of small tangible parts from their great effects. Such motions result from interactions between tangible parts and spirits. Heats moves the spirits, cold may irritate or otherwise affect them and spirit usually starts the excited movements of heat [40]. Bacon applies the interconnections among heat, spirit and tangible parts in his suggestion for making gold.

The two natural philosophies of the day, according to Bacon, are those of the Grecians and the Alchemists. The one multiplies words ; the other fails to multiply gold. The Alchemists dream vainly of nature's intention to make gold ; they dream equally vainly of a vast store of it made by projecting a little medicine on to a sea of base metal. The alchemical doctrine is so futile that it is incredible to anyone who is not an Alchemist. This philosophy is constructed out of a few experiments with a furnace, and many other vanities flourish in Alchemy. The Alchemists hope eternally, repeat their experiments endlessly to purge them of errors, nourish their dreams on occasional discoveries and die hoping [41].

Bacon, who is kind to Aristotle as well as harsh, has some kind words for the Alchemists. They are practically versed in nature in spite of their scant successes. They have successes also, though not with their projected grains of elixir. In the fable the old man bequeaths his vineyard to his sons. He tells them of gold in the vineyard before he dies, and they dig for it. They find no gold, but the digging benefits the vines and there is a rich vintage. So the Alchemists get no gold, but they do make useful discoveries.

Though imagination sways the Alchemist more than reason, his ends are noble. These ends may be partly secured : a few drops of a precious liquor are unlikely to prolong youth or delay old age more effectively than rational living, but the people of New Atlantis do make a ' water of paradise ' that benefits health and prolongs life. Those ends may be otherwise secured : it may be possible to make gold, though less freely and less dramatically than by projecting elixirs [42].

[40] *Nov. Org.*, ii, 40, 48 ; *Nat. Hist.*, i, 68, 98, 99 ; iv, 314, 335.

[41] *In Praise of Knowledge, Works of Sir Francis Bacon*, London, 1824, ii, 124 ; *Filum Labyrinthi*, Spedding &c., iii, 496 ; *Nov. Org.*, i, 54, 64, 73, 85 ; *Nat. Hist.*, iv, 326.

[42] Adv. L., i ; iii, 5 ; *Nov. Org.*, i, 5, 85 ; *Nat. Hist.*, iv, 326 ; *New Atlantis*, Spedding &c., iii, 158.

Bacon arrives through doubts at the judgment that gold can be made. His doubts depend more on the nature of gold than on the failures and follies of the Alchemists. Gold is too dense, or heavy, for the baser and lighter metals to be easily transmuted into it : rarefaction tends to prevail over condensation. Silver is more easily made than gold, even from the heavy quicksilver, because further fixation is easier than a condensing process. If a metal is to be condensed into gold by the arts of the furnace, silver is preferable because quicksilver, though already heavy, does not endure the fire. Silver, also, of all metals in nature, ' symbolizeth most with gold '. If silver is not used, copper is Bacon's next choice. The addition of one part of mercury to every ten parts of silver supplies spirit, in which quicksilver is rich, to work upon the metal. One part of nitre added to every twelve parts of silver also supplies spirit. The process must be contrived to impart to the transmuting silver the uniform closeness of parts that makes gold compact and immune from rust. The spirits do this if they are properly applied.

Silver is fixed into gold by effectively concocting or digesting or maturing the metal. To do this the spirits of the metals must be quickened, and the tangible parts must be opened. Heat has these two effects. The spirits must also work evenly and without leaps to make the parts close and pliant. A moderate heat, that does not rise or fall, secures this. The product will be too hard if any spirit is emitted, for heat hardens bodies that lose spirit, and gold is soft. Tempering the heat also helps to detain the spirits.

Bacon commends the virtues of heating bodies in closed vessels. This close distillation both keeps the air out and shuts the spirit in. Under a moderate heat it resembles the natural matrix, in which the heat expels no parts, though there is nourishment as well as warmth. The analogy of the womb probably sharpens Bacon's hopes from close distillation. Closing the vessel during the maturation assists to keep the spirits in to digest the metal steadily. Since this steady maturing requires time, the heating is continued for at least six months.

Thus Bacon's recipe for making gold is to digest silver for a long time in a closed vessel at a steady heat that will just keep the metal molten. Some mercury and nitre are mixed with the silver to supply extra spirit. Bacon adds one more aid to the transmutation : periodical introductions of oiled substance. This helps to lay the parts closely and smoothly, which is the chief aim of the process.

Bacon's recipe for making gold impresses the modern chemist no more than the projected elixir and alchemical over-firing impressed Bacon himself. His analysis of reasons and methods does give an interesting insight into his Natural Philosophy. The recipe, also, is given for trial, not urged on faith, and further thought may improve it [43].

[43] *Physiological Remains, Works of Sir Francis Bacon*, London, 1824, ii, 191 ; *Adv. L.*, v, 2 ; *Nov. Org.*, ii, 50 ; *Nat. Hist.*, i, 99. The process is fully described in *Nat. Hist.*, iv, 326–8.

There is a sure way of making gold. The metal is very heavy, compact, fixed, soft, immune from rust, and yellow. If the cause of each of these natures is known thoroughly, the causes can be applied to impose the necessary qualities on matter. The result will be *a* gold, however men may doubt that it is *the* gold. Bacon pertinently describes this sure method as roundabout [44].

The sureness of the method depends upon the fundamental nature of the simple ' forms ', as can be gathered from the ample context of Bacon's writings. Yellowness, for example, is a simple nature or quality as it appears to sense. A substance is gold if it has yellowness and the other specified simple natures—Bacon gives a somewhat different list in the *Novum Organum*. The ' form ' of yellowness in any body confers the nature upon it, for any nature inevitably follows from its ' form ' If this form is thoroughly enough known to be impressed on any body, that body is yellow. If all the other required forms are similarly imposed, the body has all the simple natures, or qualities, of gold. The modern reader is probably more impressed by the adjective ' roundabout ' than by Bacon's ' sure ' [45].

According to Bacon's terminology the uncertain recipe belongs to Physics. This science, which only supposes existence, motion and natural necessity, studies matter and efficient causes. It does not discovery constancy of cause when, for example, the same fire hardens clay and softens wax. Again, according to Bacon's terminology, the sure method belongs to Metaphysics. This science, which also discusses final causes or ends, deals more fundamentally than Physics with forms. Bacon has to be content with a recipe for trial that depends upon the efficient causes deduced by Physics from the ordinary course of nature. The sure method remains ideal, for Metaphysics has not yet disclosed completely the required immutable and eternal forms. Hope can turn from the ideal sureness to the more doubtful recipe—nature's concoction of water into oil is more remarkable than the concoction of silver or mercury into gold [46].

Genuine magic, which understands and commands nature, results from sound Metaphysics. Bacon distinguishes it from the degenerate natural magic of the superstitious tradition. Alchemy and Astrology embody this spurious magic ; genuine magic is embodied in a sound metaphysic of forms [47].

In 1694 Richard Baldwin and John Dunton, of London, published *Pleasure with Profit : Consisting of Recreations of divers Kinds*. The author, William Leybourn, included a section on *Recreations Chymical*. This section transcribed the passage from Bacon's *Natural History* that describes the Making of Gold. Did hopes still live on Bacon's recipe, as they had lived, and were still living, on the reputed powers of the Philosophers' Stone ?

In *New Atlantis* they use various furnaces, instruments to generate heat

[44] *Nat. Hist.*, iv, 328.
[45] *Nov. Org.*, ii, 4, 5, 13.
[46] *Adv. L.*, iii, 4 ; *Nov. Org.*, ii, 9 ; *Nat. Hist.*, iv, 354.
[47] *Adv. L.*, iii, 5 ; *Nov. Org.*, ii, 31.

by motion and other divers heats. They also dig cool caves, often very deeply, to coagulate, harden and preserve bodies by chill. Outside New Atlantis men use ' a conservatory of snow and ice ' to cool wine in summer—this seems a poor and contemptible use to the inquirer into nature [48].

Bacon suggests a ' form ' for cold by inference, though he does not explore it as he explores the form of heat. He reasons similarly whether the particles penetrate inwards or outwards : in heat contraction resists expansion, in cold expansion restrains contraction. This oppposition probably explains why he supposes cold to act most potently where there has been heat. Hot metals are hardened by dipping them in cold water, apparently because the cold struggles more violently against the previous expansion. Cold, like its opposite, heat, has connections with spirits [49].

According to the *Historia Vitæ et Mortis* cold things are usually poor in spirit. Dense bodies, such as metals, are usually the coldest, and most liquids are naturally cold. Quicksilver, however, though dense and liquid, has more spirit than any other metal. It is also the coldest metal, for a quick spirit in a cold body sharpens the cold into greater vigour. When salt is added to ice its quick spirit makes the cold more active, and water is colder than oil because its spirit is quicker. Bacon advises those who take nitre to cool and condense their spirits to take it in Malmsey, or Greek wine. The ' subtle spirit ' in nitre, curiously enough, scours as well as cools : curiously because warm water scours better than cold. The nitrous waters of some lakes, however, divide the sticky foulness of foul clothes by their spirit of nitre and so scour [50].

It is clear that nitre, which is colder than stone to the tongue, does contain quick spirit. Gunpowder vouches for a crude and windy spirit in nitre, or saltpetre. In the *Historia Densi et Rari* the flame of exploding gunpowder is compared to a powerful froth of air and flame that is like a fiery wind. The spirit of nitre, being crude or watery, is antipathetic to the flame from the sulphur, and the conflict between the two, as the sulphur tries to burn while the spirit of nitre expands to escape, fans the flame in all directions, as if by invisible bellows. The willow charcoal has the less boisterous rôle of incorporating the nitre and sulphur. If there is a white powder that discharges a piece without noise, it *may* be ' petre and sulphur, without coal ' [51].

Many years after Bacon the principal doctrines of chemistry seem to Black to be based on the study of nitre. The future oxygen is obscurely visible in Bacon's ' notable crude and windy spirit ' of saltpetre. It is ' crude ' because it belongs to the watery or aerial class of spirits that are inimical to flame. The ' windy ' explains itself. The efflorescence of nitre roused suspicions

[48] *Nat. Hist.*, i, 70.
[49] *Nov. Org.*, ii, 20 ; *Nat. Hist.*, i, 86.
[50] *Nov. Org.*, ii, 12 ; *Nat. Hist.*, i, 72, 73 ; iv, 362 ; x, 930.
[51] *Nov. Org.*, ii, 36 ; *Nat. Hist.*, i, 30 ; ii, 120.

of nitrous matter in the air ; according to Bacon saltpetre derives its spirit from the earth. This spirit is also said, in the *Historia Vitæ et Mortis*, to be inferior to the spirits of animals and vegetables through its earthy origin, though nitre, since it cools and restrains the spirits, favours longevity if taken in moderation [52].

Bacon obviously deduces the spirit in nitre, and its nature, from the general notions of his physics. In one experiment he collects a spirit in a bladder. The bladder is oiled to make it air-tight, squeezed free from air, and tied round the mouth of a vial with waxed thread. The vial is previously filled with spirits of wine and then weighed. When the vial is placed on hot coals in a brazier the bladder swells like a sail as the steam of the spirit dilates into it. After the bladder is fully distended to its capacity of about two pints, the vial is placed on a carpet to avoid cracking it by sudden cold. The bladder is pricked promptly to prevent the vapour from condensing back into the vial. After removing the bladder the vial and its remaining contents are weighed, and, by subtracting this from the former weighing, the weight of the evaporated spirits of wine is determined. The ratio between the volumes of the vaporised and liquid spirits of wine indicates a hundred-fold expansion. This is Bacon's description of an experiment stimulated by interest in density and rarity : an attempt to discover ' the ratio of intangible or pneumatic bodies to tangible bodies '. The pneumaticals are constantly described as weightless. The bladder is destined to receive ' airs ' *for examination*, but Bacon does not use it so [53].

Bacon contrasts the incredibility of Suetonius, when he describes the acts of Nero or Claudius in disconnected passages, and the plausibility of Tacitus when he describes the same events with circumstance and method. Severinus elegantly harmonises the scattered notions of Paracelsus into a body of philosophy. Bacon usually respects the single notions of Paracelsus less than their systematisation by Severinus. Paracelsus and the Alchemists pervert the ancient doctrine that man is the microcosm of the universe. He, and other pretenders to natural magic, exaggerate the powers of imagination into miracle. Distillations also blind Paracelsus into believing that nutrition is mere separation—of a nose concealed in bread, for example, or of a leaf in the juice of the earth. Bacon has harsh words for both Paracelsus and Aristotle ; he has some kind words for Aristotle and few, if any, for Paracelsus. In his doctrine of the elements, so far as he has one, he is nearer to Paracelsus than to Aristotle.

In the *Historia Densi et Rari* Bacon denies that there is evidence for the composition of terrestial things out of the four elements. In the *Advancement of Learning* (v, 4) he accuses chemists of a fantastic correspondence between their four principles and the heavens, air, earth and water. He speaks again of the fictitious elements and of natural bodies fictitiously formed from them

[52] Black, J., *Lectures on the Elements of Chemistry*, ed. Robison, Edinburgh, 1803, i, 426.
[53] *Nov. Org.*, ii, 40.

in the *Novum Organum* (i, 46). Bacon's natural philosophy conforms more to the Paracelsian Tria Prima than to the Aristotelian fire, air, water and earth.

Bacon, however, does not accept the triad, mercury, sulphur and salt. The 'chymists' reason absurdly about salt when they introduce it for bodies that are fixed, dry and earthy. Salt is compounded of mercury and sulphur by a strong spirit. The succeeding remark that salt is a rudiment of life itself, in the Introduction to the *History of Sulphur, Mercury and Salt* (Spedding &c., v, 205), seems to recompense Sal for its exclusion from the chemist's principles. The preservative action of ordinary salt is referred to the strength of its spirit. When salts are thrown on the fire their aqueous spirits escape with a crackling noise before the flame is produced. Thus salts avoid flame and repel it. Quicksilver, not inaptly called mineral water, manifests the same expansion without inflammation. Salts also have inflammable parts [54].

The principles sal, mercury and sulphur cannot be separated from perfect metals. The brimstone and quicksilver found in imperfect minerals are nature's remote materials, not the chemist's principles. Bacon warns chemists that when fire attacks bodies it superinduces qualities upon them. The mass of vapour from heated water is fallaciously supposed to have been in the original liquid. It is actually created by the expansion of the water under heat. Such alterations by fire promote erroneous deductions from distillations. The natures of the separated bodies do not necessarily pre-exist in the original compound, for heat alters as well as separates. It is the same with other solutions of substances. The nice conformations of bodies are more likely to be disturbed by the fire than brought to light [55]. The seventeenth-century chemists were to be constantly exercised over the ability of distillation to disclose elements or principles. In 1661 the *Sceptical Chymist* was to question whether fire and destructive distillation elicited genuine elements from bodies: there was no guarantee that the elicited products pre-existed in the bodies.

Bacon is not deceived by transmuted educts from distillations. Chemists, however, rightly affirm that their first principles, sulphur and mercury, pervade the universe. One of the most universal species of harmony manifests itself in this pervasion. There are the two great sulphureous and mercurial families. The fathers of the two tribes, brimstone and quicksilver, lie in the earth. There is a correspondence between sulphur, oil, greasy exhalations, flame and, perhaps, the substance of the stars. There is a second correspondence between mercury, water, aqueous vapour, air and, perhaps, the pure inter-sidereal æther. These two great tribes vary greatly in quantity and density of matter while agreeing in conformation. Again, metals differ in conformation from vegetables, but they agree among themselves in quantity of matter and density. The two, sulphureous and mercurial, are often associated: metals consist

[54] *Nov. Org.*, ii, 36, 50; *Nat. Hist.*, iv, 346.

[55] *Nov. Org.*, ii, 7, 40; *Physiological Remains, The Works of Sir Francis Bacon*, London, 1824, ii, 200 f.

mainly of mercury and sulphur, plants and animals contain principally water and oil, air and flame compose the inferior pneumaticals. Bacon's expositions are effectively conformed to the recognition of the sulphureous and mercurial principles. They admit antipathies between respective members of the two tribes, such as oil and water or flame and air exhibit, and they allow ' consents ', such as water and oil exhibit in plants, or air and flame in living spirits [56].

No elaborated system is consistent throughout, and most natural philosophies, if not all, present obvious defects. Bacon's system has its own constructive imperfections, but it is remarkably coherently thought out. It has the quaintness of all superseded notions ; it has also the interest of a determined and competent effort to read nature's riddles. If Bacon did nothing else in natural science he rang a bell that called the wits together. The later science of the century acknowledged the stimulus that it received from Francis Bacon, Baron Verulam, Viscount St. Albans, Lord High Chancellor of England.

[56] *Nov. Org.*, ii, 50 ; *Nat. Hist.*, iv, 354.

REVIEWS.

Arcana Artis, by G. F. HARTLAUB, in *Zeitschrift für Kunstgeschichte*, **6**, 289–324.

THIS interesting contribution, with 21 illustrations, deals mainly with several common themes which may be traced in the art of the Renaissance.

The four elements—earth, air, fire and water—were associated in the mediæval mind with the four humours or fluids of the body, and thus with the four temperaments. In particular, earth was linked with black bile and thus with the melancholic temperament. The doctrine of melancholy, moreover, is inseparable from the Saturn mysticism which permeates alchemy. Lead—the heavy, base metal—joined in alchemy with Saturn—the slow, gloomy planet—is often represented by a darkened symbol; it is also concerned in the preparation of the first material of the Great Work, possessed of the requisite black hue.

It is frequently stated in the esoteric writings on alchemy that once the primitive materials of the Stone have been obtained, the rest of the operations of the Great Work are 'only a labour fit for women, or child's play'[1]. In commenting upon the *ludus puerorum* motive in sixteenth-century art, Dr. Hartlaub refers to Cranach's quaint design, in his painting representing melancholy (1533), of fifteen infant boys at play; and there is a closely similar representation in *Splendor Solis*. These children may be linked on the one hand with the alchemical idea of regeneration, and on the other with the mythological story of Saturn (Kronos), who swallowed his own children—and thus with the idea of melancholy.

The alchemist's lot was not a happy one; and it is not surprising that serious and satirical artists alike have depicted him as a melancholy being. An association between alchemy and melancholy seems, indeed, to have been widely recognized in the sixteenth century. Dr. Hartlaub brings forward many evidences of this association, one of the most interesting being Dürer's celebrated representation of melancholy, with its crucible, balance, child, rainbow, and other objects of possible alchemical significance.

It may even be that alchemical music[2] was endowed with the dual rôle of dispersing the melancholy of the adept and influencing favourably the operations of the Great Work within the Hermetic Vase. The first rôle seems to be indicated in an illustration reproduced by Dr. Hartlaub from Brunschwick's *Distillierbuch* (1508), in which a musical David plays the harp before an alchemical Saul (who is fortunately without the javelin which he might well have possessed as a symbol of mercury or of fire!).

Other themes discussed in this suggestive contribution to alchemical symbolism in art are the polyhedron (shown for example in Dürer's 'Die Melancholie'); the balance (again associated with Saturn); the *opus mulierum*; the interior of the earth and meditation; and the dragon, skull and Walpurgis night.

Dr. Hartlaub has handled a difficult subject with knowledge, insight and imagination. The intricacies of this strange but fascinating field may be

[1] See Read, *Prelude to Chemistry*, London, 1936, 134, 238, 243.

[2] *Ibid.*, 246.